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WEEKLY 25 July 2020

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This week's issue

On the cover

30 99% of what we eat is a mystery
The emerging science of nutritional dark matter

New Scientist

99% OF WHAT WE EAT IS A MYSTERY

The emerging science of nutritional dark matter

Vol 247 No 3292
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11 The evidence for face masks
14 Alzheimer's in the gut
9 How Australia lost control of covid-19
36 The return of analogue computing
12 A new push for Mars

18 Campfires on the sun
24 Brave New World: The TV show
19 How sea turtles get lost

42 Features

"Wherever you live, there is damage from extreme weather caused by climate change"

News

7 Vaccine hope
Oxford trial delivers promising immune response

14 Alzheimer's in the gut
Protein linked to the condition may not start in the brain

15 Universal mystery
Astronomers can't agree on how fast the cosmos is growing

Views

21 The columnist
The sudden end of normal activity is helping rewilding efforts, says Graham Lawton

22 Letters
Nowhere responded to covid-19 quickly enough

24 Culture
A dystopia without lessons for the modern world

25 Culture
What happens when a pandemic wipes out men?

28 Aperture
Ethereal shots of our universe

Insight

KATE MCSHANE/GETTY IMAGES

16 Obesity and the pandemic We still don't know the best way to get slim

Features

30 99% of what we eat is a mystery
There's a giant hole in our knowledge of what is in our food

36 Analogue comeback
Why digital technology is getting a helping hand

42 Feeling the heat
Climate scientist Friedrike Otto on what causes extreme weather

The back pages

53 Puzzles
Cryptic crossword and the quiz

54 More puzzles
A stripy flag, a pair of scissors and a problem to solve

54 Cartoons
Life through the lens of Tom Gauld and Twisteddoodles

55 Feedback
Social distancing with Australia's deadly fauna

56 The last word
Why don't trees get really wide? Readers respond

Elsewhere on New Scientist

Virtual events

The science of sin

Neurobiologist Jack Lewis sheds light on the fascinating topic of temptation – where it comes from, how to resist it and why we all succumb to it from time to time. Thursday 30 July at 6pm BST.

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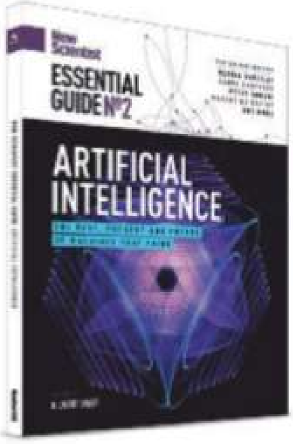

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A pair of pandemics

In our fights against covid-19 and obesity, our best weapon is research

FOR months now, UK prime minister Boris Johnson and his ministers have been repeating a mantra for tackling the coronavirus pandemic: follow the science. Debates about "the" science aside – the UK government seems to have had too many modellers and not enough public health experts advising it – an approach based on evidence is always a good one.

Evidence, however, can sometimes be lacking. On 29 January, early in the pandemic, the World Health Organization published a guide on the use of medical masks by the general public to slow the spread of the virus. It said that compulsory mask wearing shouldn't be required, as "no evidence is available on its usefulness to protect non-sick persons".

It is easy to read those words and assume that face coverings of any kind are pointless – indeed, that is precisely what many people have done. But as the saying goes, absence of evidence is not evidence of absence. Rigorous studies on mask wearing have simply not been done, so we cannot say for sure that they work. We also cannot say that they don't.

"The two pandemics have become interlinked, with obesity a factor in some cases of severe covid-19"

Now, though, new evidence is trickling in. As a result, official policy in many countries, including in England (see page 11), is changing. We still don't have the gold standard of medical evidence – a randomised trial – but as we learn more about how the coronavirus is transmitted, face coverings seem a sensible idea.

Not content with fighting one pandemic, Johnson has also signalled his intention to begin battle with another: obesity. Of course, the two pandemics have become interlinked, with obesity a factor in the development of some cases of severe covid-19.

However, despite obesity having been around for a great deal longer than covid-19, the evidence on what to do about it remains surprisingly contradictory, with dieticians at loggerheads over whether the most effective approach is to reduce how much fat or carbohydrate we eat (see page 16). To find out, we need more long-term research. Only then can we follow the science. ▮

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CONTACT US

newscientist.com/contact
General & media enquiries
Tel+44 (0)20 7611 1202
UK **Tel**+44 (0)20 7611 1200
25 Bedford Street, London WC2E 9ES
Australia 418A Elizabeth St, Surry Hills, NSW 2010
US PO Box 80247, Portland, OR 97280
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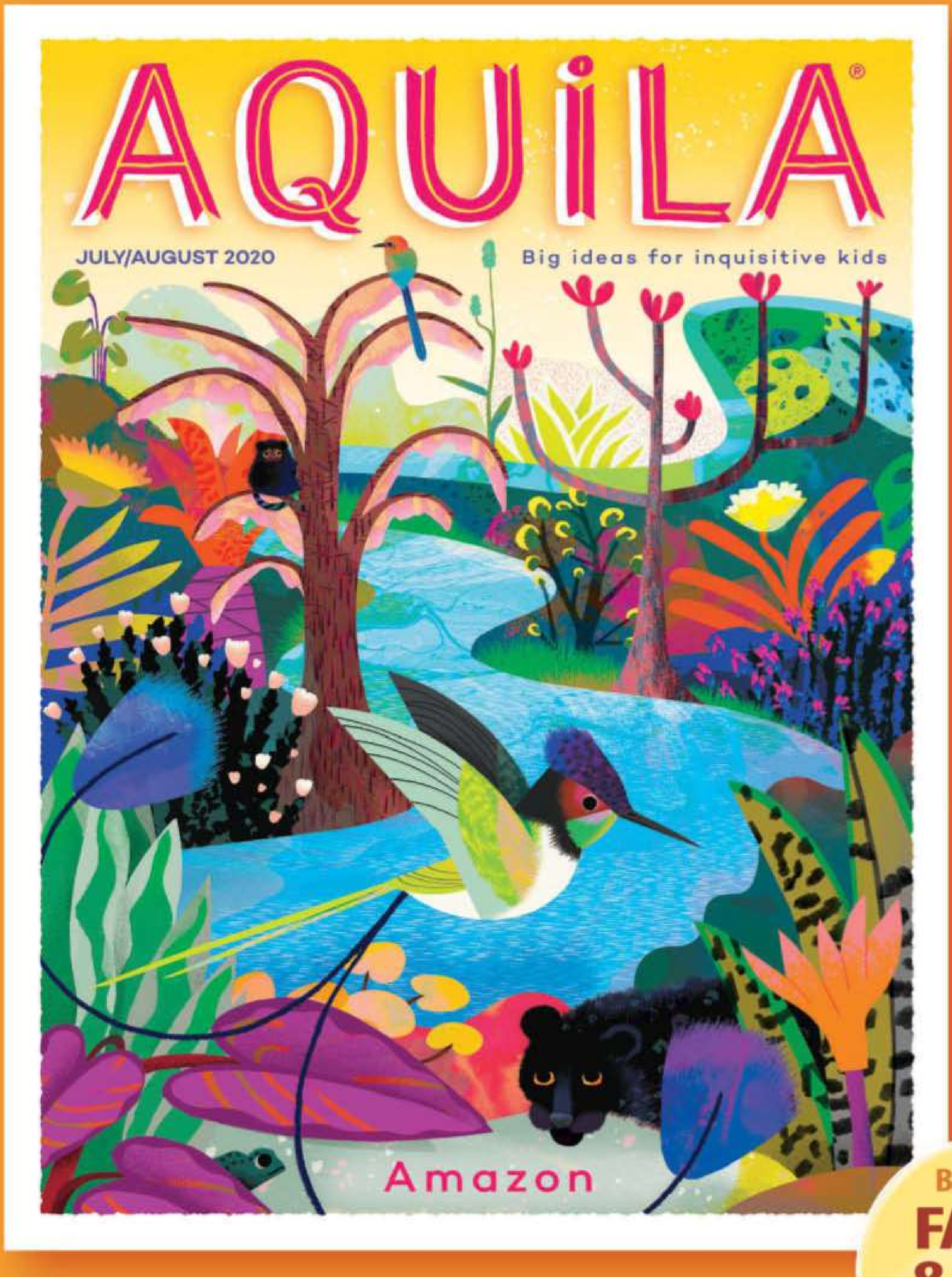

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SIPHIWE SIBEKO/AP/SHUTTERSTOCK

An early volunteer for an Oxford vaccine trial in Soweto, South Africa

Vaccine immune boost

An early trial of a vaccine candidate from the University of Oxford has produced a promising immune response, reports **Michael Le Page**

AN EXPERIMENTAL coronavirus vaccine developed at the University of Oxford produces the hoped for immune responses in people. Even though it isn't yet clear if this means the vaccine will prevent infections, the group that made it has struck deals for companies to make 2 billion doses of it within a year.

"It's a really important day today," says team leader Sarah Gilbert. "But there's still a long way to go."

At least 23 experimental vaccines are being tested in people. The aim of these trials is to prove that the vaccines work, but that will take time, because it requires giving the vaccine or a placebo to many thousands of people in a region where there are lots of coronavirus cases.

The latest findings were the result of a smaller trial intended to study the immune response to find out if the vaccine is safe and produces the intended effect. About 1000 volunteers were given the Oxford vaccine, which uses a chimpanzee cold virus to deliver the gene for the coronavirus spike protein to human cells.

The modified virus can't replicate, so can't cause infection itself. No serious adverse effects were reported in the study, published this week (*The Lancet*, doi.org/gg5gwk).

The volunteers did generate lots of antibodies, proteins that circulate in the blood and bind to viruses. Not all antibodies bind in a way that renders the virus harmless, but after one dose most volunteers produced neutralising antibodies, which do prevent viruses infecting cells. After two doses, all the volunteers generated neutralising antibodies.

Their bodies also made immune cells known as T-cells that seek out and destroy infected cells before they produce more viruses. This cellular response is thought to be an important part of immunity to the coronavirus. "We are super-excited by these results," says team member Teresa Lambe.

The antibody response is comparable to that seen in natural infections, but the cellular response is stronger. However, it remains to be seen whether this response is sufficient to protect against infection and how long this protection lasts.

Even if immunity fades fast when people are infected with the coronavirus itself, that doesn't necessarily mean vaccine-induced immunity will do the same, says team member Adrian Hill. "It's wrong to assume that," he says.

It is also unclear how well the vaccine will protect older people, who are at greater risk from covid-19 and have a smaller response to flu vaccines. The Oxford trial involved only people aged between 18 and 55.

> **"After two vaccine doses, all the volunteers produced antibodies that prevent viruses infecting cells"**

In a paper published alongside the Oxford one, a team in China reported results from a trial in which 603 volunteers were given a dose of a similar vaccine, called Ad5. It found that the immune response was lower in people aged over 55 (*The Lancet*, doi.org/gg5gwj).

These studies aren't the first of their kind. US company Moderna has found that its experimental vaccine provoked protective responses in 45 people. It has now entered into larger, phase III trials.

The Oxford team is also entering larger trials. About 8000 people in the UK have already been given the vaccine, and the trial is being extended to include people over the age of 55. Trials are also starting in the US, Brazil and South Africa. Because the number of covid-19 cases are higher in these countries, these trials may yield results sooner.

Pharmaceutical firm AstraZeneca is already gearing up to produce 1 billion doses of the Oxford vaccine, and the Serum Institute of India has also agreed to make a billion. These will be produced on a non-profit basis while the pandemic lasts. ▮

Daily coronavirus news round-up
Online every weekday at 6pm BST
newscientist.com/coronavirus-latest

Analysis Mental health

The mental health toll of the covid-19 pandemic becomes clear

Anxiety and depression are elevated as people struggle with illness, isolation and uncertainty, finds **Adam Vaughan**

"EVERYTHING just went haywire. My moods were all over the place," says Black actor and producer Dami Adeyeye, as he describes the perfect storm of living with his family under lockdown in the UK, watching police brutality in the US after the killing of George Floyd and seeing a UK government report showing that covid-19 is deadlier if you are from a Black, Asian and minority ethnic (BAME) background.

Adeyeye has had depression in the past and isn't alone in grappling with his mental health at this time. Across the UK, a greater percentage of people from a BAME background than from a white one said concerns over jobs, housing and money damaged their mental health during the pandemic, according to a survey of 14,000 adults with existing mental health issues by the UK charity Mind.

The research is part of a growing wave revealing the contours of the pandemic-related mental health crisis many experts predicted.

People treated for covid-19 in intensive care units have a higher risk of depression and anxiety, with about 40 per cent likely to have post-traumatic stress disorder. That could amount to tens of thousands of people in the UK, says Tom Dening at the University of Nottingham. Covid-19 can also result in neuropsychiatric problems.

Indirectly, the coronavirus has also had sweeping effects on the mental health of many. "The general population is suffering the effects of uncertainty, isolation, disruption of their social networks, fear of getting the illness, worrying about family, concerns about employment, education and money," says Dening.

Anxiety and depression levels rose in the UK and other countries in the run-up to covid-19 restrictions being implemented and have stayed above average during lockdowns. "It's not affected everybody equally," says Daisy Fancourt at University College London, a researcher working on a study of the mental health of 50,000 people in the UK during lockdown (medRxiv, doi.org/d378). "[During lockdown] younger adults have had worse mental health across every single measure, including life satisfaction, suicidal thoughts and self-harming. Results are also worse among lower income households and people living alone."

MARIO TAMA/GETTY IMAGES

A covid-19 patient in Colorado is released from hospital after five weeks

> **"In the UK, elevated levels of anxiety and depression have been stable, marking this pandemic apart"**

Older people have seen less of a blow to their mental health. Dening, who specialises in dementia, says some of his patients have been surprisingly unaffected. "Some of the people I was initially worried about, because they have such isolated lives, have actually coped very well. They had skills in living this way that other people had to acquire," he says.

People in the UK who are married or in a civil partnership saw double the pre-pandemic levels of anxiety, according to the UK Office for National Statistics. The ONS says the trend may be because these people are more likely to have children and are struggling to balance home-schooling with work.

Overall, 37 per cent of adults in Great Britain at the start of May had high levels of anxiety; before the pandemic began, it was 21 per cent, according to the ONS. Other countries have seen similar rises. By 1 July, a study of more than 56,000 people in China found that 31.6 per cent had symptoms of anxiety, compared with 5 to 6 per cent before the pandemic (*JAMA Network Open*, doi.org/d379).

Mental health services may be struggling to help the people most severely affected. A separate study by Fancourt and her colleagues found that three in five adults in the UK who had suicidal thoughts during the pandemic didn't have professional support (*The British Journal of Psychiatry*, doi.org/gg42sn).

In the UK, the level of elevated anxiety and depression has been stable under lockdown, marking this pandemic apart from previous epidemics such as SARS. With SARS, the sudden nature of quarantines saw mental health decline over 28 days and then rebound. The smaller number of people affected meant those individuals were upset by activities they were missing. With covid-19, many were affected simultaneously so there was little to miss, and they could see it coming so their mental health became worse in anticipation, before levelling off.

Fancourt fears that with lockdowns easing, population-level data on depression and anxiety may mask deteriorations for some. Some people are returning to more normal life, but others may experience a fear of missing out while under local lockdown, which may be more traumatic than earlier lockdowns that affected everyone, she says.

Music, reading and film-making have lifted Adeyeye through the pandemic. For Katie Scott, a student in Reading, UK, who found her eating disorder came back due to the social isolation of lockdown, society's wider return to normality has helped. "I've started seeing my friends and can go out, go shopping and go for drinks. It's definitely improved," she says.

Need a listening ear? UK Samaritans: 116123 (samaritans.org); US National Suicide Prevention Lifeline: 1 800 273 8255

Global spread

Australia sees a new virus surge after nearly eliminating covid-19

Alice Klein

AUSTRALIA was tantalisingly close to eliminating the coronavirus, but is now seeing a surge in new cases. What went wrong and can it regain control?

The country was initially able to contain covid-19 by closing its border to everyone except citizens and permanent residents, quarantining those who returned home from abroad, implementing stay-at-home orders throughout the country and conducting widespread testing and contact tracing.

24

Deaths related to the latest coronavirus outbreak in Australia

This brought the number of new confirmed cases down from 460 on 28 March to between two and 17 per day in early June. Since mid-June, however, there has been a resurgence, with around 300 to 400 new cases now being reported in the country daily. As of 21 July, Australia has passed 12,000 cases and recorded 126 deaths, 24 of which are linked to the latest outbreak.

Most of the new infections are occurring in the state of Victoria (see graph, right), with a smaller outbreak in neighbouring New South Wales.

Victoria's covid-19 spike cannot be pinned to its lifting of stay-at-home orders or its testing strategy, since its policies have closely matched those in the rest of Australia, which has remained relatively virus-free.

Like other states and territories, Victoria started to relax its stay-at-home orders in mid-May. It also offers tests to anyone with even mild cold or flu symptoms and conducts extensive contact tracing. Instead, the new outbreak appears to be related to quarantine facilities.

Despite Australia's border being closed since 20 March, Australian citizens and permanent residents have been allowed to return home on the condition that they stay in supervised quarantine hotels for two weeks. Most states and territories have deployed police and defence personnel to manage these facilities, but Victoria employed private security contractors.

Several contractors have since caught the virus from quarantined individuals, allegedly due to breaches in infection control measures, and then spread it to the wider community. Genomic sequencing of the virus has linked a significant number of the state's new infections back to these security guards. The Victorian government has launched a judicial inquiry.

"Experience in other countries such as Singapore or [South] Korea has shown that the novel coronavirus will exploit any weakness in the public health system," says David Paterson at the University of Queensland. "Victoria's weakness appears to have been leakage from quarantine."

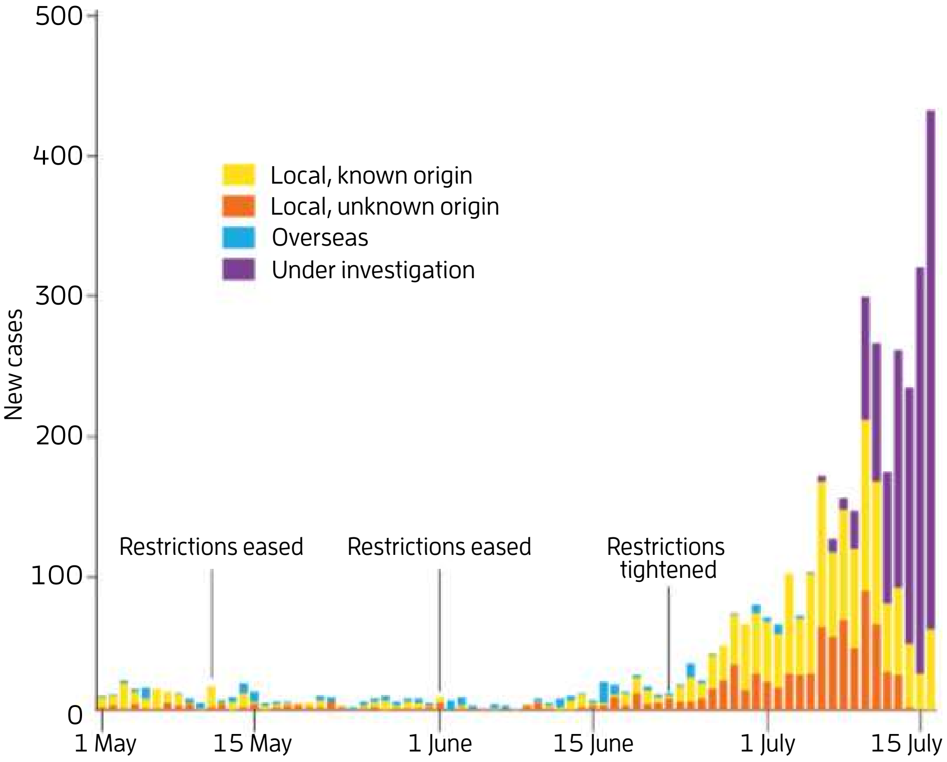
The virus's spread has been accelerated by large get-togethers that violated Victoria's limit of five guests to a home at a time. Because it is winter in Australia, people are also tending to gather inside, where respiratory viruses spread more easily, says Taghrid Istivan at RMIT University in Victoria.

Back to lockdowns

The virus has also entered Melbourne's public housing towers, where it has rapidly spread among closely packed residents.

To try to contain the virus, the Victorian government placed the affected tower blocks into a five-day "hard lockdown" on 4 July, during which time residents had to stay in their apartments. Officials also asked the residents to take tests for the virus and set up pop-up testing clinics in other covid-19 hotspot neighbourhoods.

In Victoria, Australia, most new coronavirus cases with a known source are from local spread



SOURCE: HEALTH AND HUMAN SERVICES VICTORIA. LAST UPDATED 17 JULY 2020

On 8 July, stay-at-home orders were reintroduced for all Melbourne residents for six weeks, meaning they can only leave home to buy food, access medical care, exercise or go to school or work. Restaurants and cafes aren't allowing diners to eat in, and pools, playgrounds and gyms are closed.

These lockdowns should start to reduce new cases in the next week or so, says Hassan Vally at La Trobe University in Victoria. "I'm very optimistic that we'll be able to gain control again," he says.

In New South Wales, a smaller outbreak is centred on a Sydney pub that was visited by a Melbourne truck driver with covid-19. A total of 50 staff, patrons and their contacts now have the virus.

New South Wales isn't currently planning to reimpose stay-at-home orders, which is reasonable because case numbers there are still low, says Fiona Stanaway at the University of Sydney.

"Lockdowns are really effective at stopping transmission, but you want to reserve them for when you really need them because they have such an impact on people in terms of loss of jobs and mental health," she says.

The resurgence of the virus in Australia shows that people must stay vigilant, says Vally.

"As a community, we probably got a bit complacent – we felt we'd done the hard yards and were on the path back to pre-covid life," he says. "This is a reminder to keep up social distancing, handwashing and wearing masks – we can't get too relaxed." ■

Elimination

Is wiping out the virus worth it?

The UK could eliminate coronavirus, scientists say, but it might not be the best approach

Jessica Hamzelou

PHIL WALTER/GETTY IMAGES

New Zealand is the only country where Parkrun events have resumed

BECOMING a covid-19-free zone sounds like the ultimate goal for any nation. Several countries around the world have come pretty close and, according to a group of independent scientists, the UK could join them. The group says that, as an island nation, the UK could introduce specific measures over the next year and follow in the footsteps of other island success stories, such as Iceland, Taiwan and New Zealand.

But closer scrutiny reveals that no country has truly eliminated the coronavirus from its shores and that doing so would mean making such large sacrifices in other areas of public well-being that it might not be worth it.

Earlier this month, Independent SAGE – a self-appointed group of scientists that provides advice with the intention of guiding UK government policy on the coronavirus – published a report recommending that the UK aims for zero reported cases, known as elimination, within the next 12 months.

"Achieving elimination would allow all social distancing measures to be lifted, schools to be fully open, the hospitality and entertainment industries to reopen fully, revitalisation of the economy and a sense of much needed normality for the population," the report said.

All the researchers *New Scientist* contacted agreed that elimination is a worthy goal. Most say it is theoretically possible for many countries, including the UK, to rid themselves of the virus even without a vaccine.

Success would require tough measures, however. The steps suggested in the Independent SAGE report are familiar ones. They include boosting test, trace and isolate programmes, maintaining lockdown policies and strictly restricting travel.

Such measures would be a departure from the current phased return to normal life proposed by the UK government. It recently advised people to return to office working and will soon offer discounts on restaurant meals to encourage dining out. Recent figures suggest England's test and trace programme is only reaching about 80 per cent of infected people's contacts, and it is unclear how many of those told to isolate are doing so.

80%

Estimated proportion of infected people's contacts being reached by contact tracers in England

Tight restrictions on travel and border control would have costs for business, tourism and the broader economy.

The steps needed to move to elimination would have other costs. "It's really difficult to know [what the goal should be]," says Kathleen O'Reilly at the London School of Hygiene & Tropical Medicine. "It's all about balancing what's feasible, what resources you have available and what the disadvantages are with putting your resources into one disease."

Even those countries that have come the closest to reaching elimination are now in a constant battle to keep things that way. New Zealand was tentatively described as "virus free" early in June, when all restrictions except tight border controls were lifted. But the country has been reporting small numbers of new cases of covid-19 on a near-daily basis for the past month. As of 21 July, the Ministry of Health reports 27 active cases in managed isolation and quarantine. More individuals there could have symptomless infections, says Rajiv Chowdhury at the University of Cambridge. Scotland looked like it was close to elimination at the end of June, but it is still seeing a number of new daily cases.

Elimination is worth aiming for if all we want to do is put an end to covid-19, says O'Reilly. But lockdown has already significantly affected other areas of healthcare provision. In the UK, elective medical procedures have been delayed, cancer screening has been put on hold and thousands of people have avoided seeking care for serious health issues, including for heart attack symptoms.

The balance is an even greater challenge in countries with more limited resources. Those that were well on the way to eliminating polio and measles via widespread vaccination efforts, for instance, have had significant setbacks due to the diversion of healthcare resources during the coronavirus pandemic. "Polio virus is now spreading more, certainly in some African populations and in Pakistan," says O'Reilly.

Given these difficulties, some scientists are proposing an alternative approach: eliminating the coronavirus as a public health concern. In practice, this would mean there are so few cases that people would be unlikely to come into contact with an infected person while on an outing or visiting a restaurant, says O'Reilly. But how this relates to actual case numbers is unclear.

The Independent SAGE group suggests that having one case per million people in a population could be used to define having the coronavirus "under control", but group member Gabriel Scally admits that this figure isn't based on hard evidence about how the virus spreads.

Even this goal would mean significant, prolonged changes to behaviour in terms of social distancing, personal hygiene and mask wearing. "From what I've seen so far, I'm not hopeful," says Chowdhury.

Eradication – having zero global cases of the virus – is an even bigger challenge. We have only ever eradicated one human disease, smallpox. That came about through a massive global effort, helped by a very effective vaccine. It was also much easier to see who was infected with the smallpox virus. For now, eradication of the coronavirus seems impossible. Even if a vaccine were developed, we don't yet know how effective it would be or how long its effects might last.

Attempts to eliminate – or at least significantly lower – cases in one nation must also consider the global picture. "We have to tackle this as a world issue," says Stephen Griffin at the University of Leeds, UK. This is why the US government's decision to pull out of the World Health Organization is so "unproductive", he says.

"We have to act together," says Griffin. "If we don't, we're going to have real trouble for the foreseeable future." ▮

Briefing

Face coverings now required

The new policy in England is based on evidence that they limit the spread of coronavirus, finds **Clare Wilson**

SINCE the beginning of the coronavirus pandemic, face coverings and masks have become ubiquitous in some countries, but the UK has generally been more reluctant to adopt them. This week, the law in England is changing.

What are the new rules?

People will have to wear face coverings inside shops and supermarkets in England from 24 July, unless they have certain disabilities or are under the age of 11. They already have to wear coverings while using public transport and in hospitals.

Although store workers aren't expected to enforce the rule, people who break it could face a fine of up to £100 if police get involved. This brings England more into line with restrictions in Scotland and many other European countries.

Weren't face coverings supposed to not do much good?

At the start of the pandemic, many scientists said there wasn't enough evidence to support their use. There were concerns they could encourage people to take risks such as getting closer to others, and as masks still let in some virus, overall exposure could increase. There were also fears that the public would buy medical-grade masks when hospitals were going short.

What has changed?

Cheap masks and face coverings are now widely available in shops, and as UK Prime Minister Boris Johnson said: "The scientific evidence of face coverings, and the importance of stopping aerosol droplets… that's been growing."

His spokespeople haven't clarified which studies he was referring to, but noted that the World Health Organization recently changed its advice on face coverings, saying new data showed they could provide "a barrier for potentially infectious droplets", and acknowledging that airborne droplets may be more of a concern than previously thought.

What is the evidence that face coverings can protect us?

We still don't have the best kind of medical evidence: large randomised trials showing that people who cover their face are less likely to catch the virus than those who don't. But a study last month examining a coronavirus outbreak on a US aircraft carrier showed that those who wore face coverings had a lower chance of infection than others, at 56 per cent compared with 81 per cent.

There is also clear evidence that face coverings stop people from spraying droplets into the air when talking. The UK's Royal Society recently reviewed all the research and concluded that good-quality face coverings are effective at protecting both the wearer and those around them from transmission.

HOLLIE ADAMS/GETTY IMAGES

Customers wear face masks while shopping in London

How should a face covering be worn?

It should be fitted correctly, ideally looping around the ears or the back of the neck, and covering the mouth and nose. Home-made cloth masks should be made from tightly woven fabrics, like cotton or denim. Multiple layers work best.

Why are shops being singled out for face coverings?

There is no reason shops should be more risky than other indoor spaces where people mix, such as bars or restaurants. Face coverings are clearly impractical while people eat and drink, though. UK health secretary Matt Hancock said last week that they won't be needed in offices. Part of the reason for mandating face coverings in shops is to help protect store workers and to "give people more confidence to shop safely", which will help the economy.

> "Face coverings are effective at protecting both the wearer and those around them"

Are there any downsides to wearing face coverings?

There is a chance they will encourage risky behaviour, such as gathering with others or spending time in enclosed spaces, so it is vital that people continue to wash their hands frequently and social distance. Face coverings can also hinder communication for those who are hard of hearing or who have learning disabilities. ▮

Space exploration

Missions to Mars begin

An orbiter called Hope is the first of three missions blasting off this month

Leah Crane

THE United Arab Emirates (UAE) is headed to Mars. The Emirates Mars Mission's Hope orbiter has now embarked on a seven-month journey to the Red Planet, where it will study its atmosphere and weather.

Hope blasted off from the Tanegashima Space Center in Japan aboard a Japanese rocket on 20 July at 6.58 am local time. The launch had been delayed twice due to bad weather. If all goes well, the spacecraft will arrive at Mars in February 2021. This will make the United Arab Emirates just the fifth spacefaring power to reach the planet, after the US, the Soviet Union, the European Union and India.

Once Hope is orbiting Mars, it will measure the atmosphere daily to try to trace how the weather and climate there changes. "The geology of Mars has been studied quite extensively. We are only just getting started on the atmosphere," says Sarah Al Amiri, the UAE's minister for advanced sciences and the science lead for the mission.

The spacecraft carries three scientific instruments: a camera to take high-resolution images of Mars's surface and look for water ice; an infrared spectrometer to measure dust, ice and water vapour in the lower atmosphere; and an ultraviolet spectrometer to measure the composition of the upper atmosphere.

Rather than simply circling the planet, Hope will follow an elliptical orbit that will bring it relatively close to the surface – about 20,000 kilometres up – every 55 hours. This will allow it to observe the same locations at different times of day, building a model of how the weather responds to changes in sunlight throughout the day.

Observing Mars's weather in such detail will hopefully help researchers understand not only the day-to-day conditions on the planet, but also the more extreme weather events like the colossal dust storm that engulfed the whole planet and killed NASA's Opportunity rover in 2018.

The Emirates Mars Mission's Hope orbiter will study Mars's atmosphere

MBRSC

It could also help us figure out how Mars has changed since its formation. Planetary scientists think that Mars used to be warm, damp and possibly habitable, but for some reason lost the bulk of its atmosphere over the course of billions of years, which turned it into the dry, cold and inhospitable world it is today.

"We want to find out how it went from a dense, much wetter atmosphere to a dry and very thin atmosphere," says Al Amiri. Hope will measure the gas that is still leaking away from the Martian atmosphere in an effort to understand how that process may have worked and how it is continuing now.

The mission marks the start of a busy period for Mars missions. Right now, Mars and Earth are relatively close together, a conjunction that only happens once every two years. Later in July, China's space agency aims to send an orbiter, lander and rover to Mars. Shortly after that, NASA plans to launch its Perseverance rover. If these missions are unable to take off while Mars is nearby, they will have to wait until 2022 for another chance. ▮

Robotics

Robots can now give personalised massages at home

YOU can now get a back rub without needing another human, thanks to new robot masseurs. French firm Capsix Robotics and researchers at the University of Plymouth in the UK have both made robots that can give personalised massages.

The Capsix model is available to rent, but not buy, and has a robotic arm with sensors and a camera that allow it to adapt to the individual user's body shape. It has been programmed with a range of massage protocols developed by physiotherapists, and users can adjust the firmness of the massage.

François Eyssautier at Capsix, who engineered the robot, says more than 4000 people have tried it and most have enjoyed it. Some people are a bit unsure at first, but "after 3 or 4 minutes, they forget it's a robot and just relax", he says.

A robot masseur is particularly useful in the covid-19 era when close contact with others isn't recommended, he says. "Also, sometimes we don't want to be touched by other people, we just want to relax on our own."

The University of Plymouth robot is still at the research stage. It works in a similar way, but can be customised even further. Users teach the robot to perform the movements they like by physically guiding its arm in a training session (*Frontiers in Neurorobotics*, doi.org/d377).

However, there is a long way to go before robot masseurs can be as good as human ones, says Shane Kertanegara, a physiotherapist based in Sydney, Australia. "A human physiotherapist can feel where someone is tight and concentrate on that spot, but a robot can't get that sensory feedback and adjust its manual therapy accordingly," he says. ▮

"Sometimes we don't want to be touched by other people, we just want to relax on our own"

Alice Klein

Space

Black hole clusters could explain dark matter's nature

Leah Crane

IF BLACK holes formed in the first seconds after the big bang, they may still be around in colossal clusters that are practically invisible.

In the very early universe, everything was so dense that the radiation that filled the cosmos could have collapsed to create primordial black holes. If these black holes have survived, they could have become much smaller – and thus harder to detect – than black holes that formed the usual way, through the collapse of a giant star.

Juan García-Bellido at the Autonomous University of Madrid in Spain and his colleagues ran more than 5000 simulations to see how these clusters could have evolved.

They found that there could now be clusters of black holes – each hole about the mass of the sun and just a few kilometres wide – stretching across thousands of light years. Their gravitational jostling could end up ejecting black holes from the cluster at about 1000 kilometres per second (arxiv.org/abs/2006.15018).

While this implies that there are hard-to-detect black holes hurtling through space at high speed, García-Bellido says there is no reason to worry. "The chances that one of these black holes, which have been slingshotted from one of these clusters, may hit the solar system anytime soon is one in many, many billions of trillions," he says.

The researchers found that the clusters of black holes and the free black holes that they send flying across the universe should behave in very similar ways to dark matter, a mysterious substance whose existence we can only infer from its gravitational effects on the objects around it.

That means that if primordial black holes are out there, they may be the solution to the long-standing question of what makes up dark matter, says García-Bellido. ▮

Archaeology

First Americans arrived much earlier than thought

Michael Marshall

MADS THOMSEN. RIGHT: CIPRIAN ARDELEAN

Tools found in the Chiquihuite cave in Zacatecas, Mexico, suggest humans arrived there early

HUMANS seem to have been living in the Americas as early as 33,000 years ago – 15,000 years before the most widely accepted date. The finding implies that people arrived there before the peak of the last glacial period and there is a long American prehistory we are yet to uncover.

The first American settlers were probably *Homo sapiens*, but we can't rule out extinct groups like Neanderthals and Denisovans. The settlers probably entered from north-east Asia across a land bridge linking Asia and Alaska. This was submerged by rising seas when the ice sheets melted at the end of the last glacial period.

Most archaeologists accept that humans were in the Americas 18,000 years ago. Now two studies bolster the idea that people got there much earlier.

Ciprian Ardelean at the Autonomous University of Zacatecas in Mexico and his colleagues have spent the past decade excavating Chiquihuite cave in Zacatecas. They have found almost 2000 stone tools buried in sediments in the cave, including blades, points and scrapers. No human remains or DNA have been found.

The youngest samples of sediment are at least 12,200 years old, and the oldest may be 33,150 years old (*Nature*, DOI: 10.1038/s41586-020-2509-0). This suggests that people lived in the Americas before a crucial event: the last glacial maximum – the peak of the last glaciation. Between 26,500 and 19,000 years ago, ice sheets extended across much of North America. This was thought to make condition too harsh for people to enter the Americas, but the new findings suggest humans were already present.

33,000

years ago – when humans may have first entered the Americas

The second study compiles reliably dated archaeological sites to track the spread of people across North America. Lorena Becerra-Valdivia at the University of New South Wales in Australia and Thomas Higham at the University of Oxford, who are also on Ardelean's team, assembled dates from 42 sites in North America and north-east Asia. Chiquihuite cave was the oldest reliably dated site (*Nature*, DOI: 10.1038/s41586-020-2491-6).

During and just after the last glacial maximum, North America seems to have been sparsely populated, with numbers exploding about 14,700 years ago as the ice receded, says Becerra-Valdivia.

The two studies offer "strong evidence for an earlier presence of humans in North America than has been fully accepted", says Deborah Bolnick at the University of Connecticut.

Until now, it has been widely assumed that only modern humans reached the Americas, since groups like Neanderthals died out millennia before anyone was thought to have got there. Ardelean says we shouldn't assume that any more. "I don't see why other species wouldn't have entered America," he says.

But Bolnick and Becerra-Valdivia both say the first Americans were most likely to have been modern humans. ▮

Neuroscience

Alzheimer's may begin with a protein in the gut

Alice Klein

ALZHEIMER'S disease may be caused by the abnormal build-up of a protein in the gut that then spreads to the brain, according to research in mice.

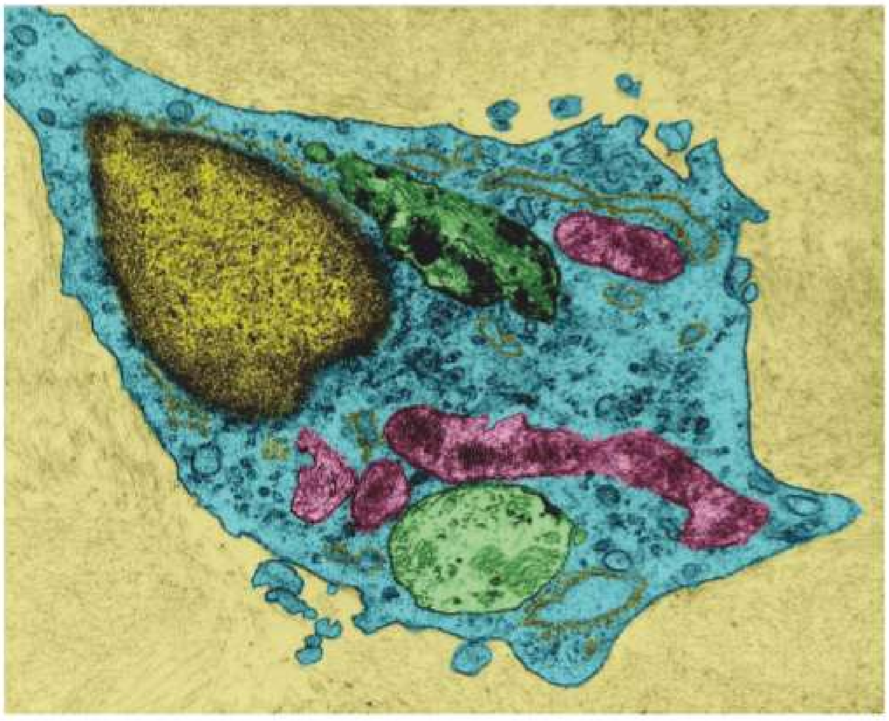
In people with Alzheimer's disease, a protein known as beta-amyloid clumps together in the brain to form plaques that disrupt normal brain processes. Beta-amyloid deposits have also been found in the guts of people who died with the condition, but these have been largely overlooked.

John Rudd at the Chinese University of Hong Kong and his colleagues wondered if the beta-amyloid found in the brains of people with Alzheimer's disease may have originated in their guts.

To test this idea, the researchers injected small amounts of the protein into the gastrointestinal tracts of mice. The beta-amyloid had a fluorescent marker attached so it could be traced.

The protein was rapidly taken up by the complex cluster of neurons that line the guts, which are sometimes referred to as the body's "second brain". One year later, the beta-amyloid had migrated up the vagus nerve, which connects the gut and the brain, and into the brains of the mice.

After the protein entered the brains, the mice displayed short-term and long-term memory problems similar to those seen in people with Alzheimer's disease (*The Journal of Physiology*, doi.org/d35r).



DENNIS KUNKEL MICROSCOPY/SCIENCE PHOTO LIBRARY

A neuroglia cell destroying beta-amyloid proteins

The exact role that beta-amyloid in the brain plays in causing Alzheimer's symptoms is still unclear, but if the protein is migrating there from the gut in people, it might be possible to prevent or delay the condition by removing beta-amyloid before it spreads to the brain, says Rudd. "Even if only some of the beta-amyloid load in the brain comes from the gastrointestinal tract, stopping or slowing that could give people an extra one or two years," he says.

Bryce Vissel at the University of Technology Sydney in Australia says the idea is plausible, but needs more evidence to back it up. "Alzheimer's disease can probably be caused in a number of different ways, so maybe a subset of Alzheimer's could arise through some mechanism like this, but it's just an intriguing possibility at this stage," he says.

"It may be possible to prevent the condition by removing beta-amyloid before it spreads"

One question is why beta-amyloid might accumulate in the gut in the first place. In the brain, growing evidence suggests that plaques of the protein form to trap harmful bacteria and viruses that migrate from other parts of the body. This may explain why people with bacterial gum disease and herpes simplex virus are more likely to develop Alzheimer's disease.

Beta-amyloid may also be made in the gut to fight dangerous bacteria and viruses that enter the digestive system, but this idea is still speculative, says Rudd.

The team's findings echo recent research in baboons showing that a protein called alpha-synuclein that clumps together in the brains of people with Parkinson's disease can also spread from the gut to the brain.

It will be hard to prove that Alzheimer's disease can start in the gut, but a first step may be to measure levels of beta-amyloid in the guts of healthy, middle-aged people and see how likely they are to develop the condition, says Rudd. ▮

Animals

Beetle larvae found to munch on polystyrene waste

Alice Klein

BEETLES with larvae that can digest polystyrene may help solve the world's mounting plastic waste crisis. Expanded polystyrene, which is used to make cups and boxes, is increasingly clogging up landfill and polluting oceans because it isn't biodegradable.

Until recently, no organisms were known to be able to break down polystyrene. But Hyung Joon Cha at Pohang University of Science and Technology in South Korea and his colleagues have discovered that the larvae of a north-east Asian beetle called *Plesiophthalmus davidis* can do the job.

When the researchers gave the larvae nothing but expanded polystyrene boxes to eat for two weeks, they consumed about 34 milligrams of the plastic each. The bacteria in their guts converted the long polystyrene molecules into carbon dioxide gas and chemical fragments that were excreted as droppings (*Applied and Environmental Microbiology*, doi.org/d353).

The larvae are probably able to degrade the plastic because they normally feed on rotten wood, which contains cellulose and lignin molecules that have similar structures to polystyrene, says Cha.

P. davidis is related to three other wood-eating beetles whose larvae have also been shown to degrade polystyrene: *Tenebrio molitor*, *Tenebrio obscurus* and *Zophobas atratus*.

The four types of larvae could potentially be used to break down some of the millions of tonnes of polystyrene waste that are produced each year, says Wei-Min Wu at Stanford University in California, who led the work studying the three other larvae. However, they probably couldn't chew through the whole lot, since each larva only consumes a few milligrams per day, he says. ▮

Cosmology

Universe mystery deepens

The universe is constantly expanding, but we aren't sure exactly how quickly

Leah Crane

TWO sets of measurements to estimate the rate of the expansion of the universe conflict with one another, which may be a sign that our basic understanding of the cosmos is wrong. What's more, two new attempts by astronomers to solve this problem have complicated things further.

The rate at which the universe's expansion accelerates is described by a number called the Hubble constant. There are two main sets of data that we use to estimate this key number: measurements of the cosmic microwave background (CMB), which is a relic of the first light to shine through the cosmos, and local measurements, which use observations of supernovae and other relatively nearby objects to determine how fast expansion is carrying them away from us.

But these two estimates don't agree: CMB readings from the Planck satellite indicate that the expansion is accelerating about 9 per cent slower than the rate suggested by the supernova data.

Simone Aiola at the Flatiron Institute in New York and his colleagues used the Atacama Cosmology Telescope in Chile to take new observations, calculating a Hubble constant that agrees with the Planck satellite data (arxiv.org/abs/2007.07288).

This strengthens the argument that the CMB value of the Hubble constant is correct, indicating that either the local measurements were somehow wrong or that the two values are actually different for as yet unknown reasons.

"It would be very exciting if the tension is real," says Antonella Palmese at the Fermi National Accelerator Laboratory in Illinois. "The hope is that some new physics will be needed to describe the universe and we are just starting to see that now as our measurements are becoming more precise."

Palmese and her colleagues have used measurements of gravitational waves – ripples that stretch and squeeze space-time because of the movements of massive objects – to calculate an independent value of the Hubble constant. They used data on three mergers of massive objects from the Laser Interferometer Gravitational-Wave Observatory in the US and the Virgo detector in Italy (arxiv.org/abs/2006.14961).

Their value is in between the two others, but the measurements aren't precise, so it is compatible with both. This first attempt demonstrates that gravitational waves could be a major help in solving this mystery.

"It should be very close to the local measurements, but it doesn't rely on the same type of observation, so if there is some kind of problem with the local measurements, we should be able to find it with gravitational waves," says Palmese.

If the observations remain in tension, it means that the Hubble constant changed between when the light in the CMB was emitted and now. There are many possible explanations, from unexpected properties of dark matter and dark energy to the idea that we may just live in a strange corner of the universe. ▮

The universe has been expanding since the big bang

NG IMAGES/ALAMY

Technology

Vibrating belt helps guide the way for soldiers

DUTCH soldiers are being kitted out with a belt that allows them to sense the location of waypoints, providing hands-free directions.

Haptic navigation tools, which guide the wearer through vibration, have been researched as possible aids for people with visual impairments, but are also of interest to the military. A firm called Elitac Wearables in Utrecht, the Netherlands, has delivered the first real product using the technology, selling 20 of its Mission Navigation Belts to the Royal Netherlands Army this month for an undisclosed price.

Existing navigational aids require soldiers to look down at screens or listen to audio instructions. Both have disadvantages: soldiers need to scan their surroundings at all times and light from a screen may betray their position, while verbal instructions can interfere with other communications and get drowned out by background noise.

The belt connects to the soldiers' existing smart vests, which are fitted with a radio, GPS and battery. Seven vibrational motors around the belt continuously indicate the direction to the next waypoint, with the location of the vibration changing as the wearer turns.

Soldiers tested the belts in land and water vehicles and on foot, navigating continuously between modes of travel. The haptic signals were clear even when running or traversing rough terrain.

"It has proved its value convincingly during field tests," says Van Veen, a major in the Royal Netherlands Army who was involved in the testing. "Soldiers reported that they were more aware of their surroundings and found the navigational cues very intuitive."

The belt could pave the way for other applications, says Martijn van der Leeden at Elitac's parent company Teijin, such as assisting those with visual impairments and providing hands-free navigation for hikers, runners and cyclists, but Elitac has no immediate plans for a consumer version. ▮

David Hambling

> "The belt could pave the way for other applications, such as assisting those with visual impairments"

Obesity

Get fit to stay healthy?

The UK government wants people to lose weight to reduce their risk of severe covid-19, but slimming down is no simple task, reports **Clare Wilson**

HOW can countries become more resilient to the coronavirus? You may have heard about face masks, hand-washing and avoiding crowds. But as UK Prime Minister Boris Johnson was recovering from covid-19 in May, he announced another tactic: targeting the nation's waistlines.

People who are overweight are certainly at a higher risk of developing severe covid-19, especially if they also have type 2 diabetes, which is linked to obesity. Around a third of UK adults are overweight, and roughly another third are obese. Johnson has blamed his own weight for how severely he was affected by coronavirus when he was admitted to hospital in April.

England's deputy chief medical officer, Jenny Harries, also said this month that losing weight would reduce people's chances of a severe case of covid-19 if there is a second wave in the country this winter and advised that people should get "as fit as possible".

There is just one problem: we don't actually know the best way for people to lose weight and keep it off. Many initiatives have been tried, but very few have been shown to work. "There's no country in the world that has solved this," says Michael Lean at the University of Glasgow, UK.

People in most countries have been getting gradually heavier over the past few decades, with the UK one of the heaviest countries in Europe. This seems to be exacerbating the severity of the covid-19 outbreak, researchers argued in a recent editorial in the medical journal *BMJ*.

The UK government hasn't yet released specifics of how it plans to reverse this trend, but it is unlikely to be as simple as people getting fitter, as Harries implied.

While exercise seems to help prevent weight gain, studies have shown that it doesn't cause people to lose weight, perhaps because it is hard to achieve the levels necessary to burn off a significant amount of fat. It may also make people hungrier. Physical activity seems to have a host of health benefits, including protecting against heart disease and boosting mental health, but weight loss isn't one of them.

KATE GREEN/GETTY IMAGES

Exercise has become more challenging with gyms closed in lockdown

1 in 6

Overweight US adults able to lose 10 per cent of their weight and keep it off for at least a year

"While exercise seems to help prevent weight gain, it doesn't cause people to lose weight"

"People who are no longer young and have become heavy find it enormously difficult to exercise enough to have any meaningful effect on weight," says Roy Taylor at Newcastle University in the UK.

Going on a diet may seem the obvious way to lose weight, but while losing weight this way is possible, if unpleasant, keeping it off is much harder. Most people who lose weight through dieting regain most if not all of it within a year or two and some end up heavier than when they started.

Figures are hard to come by, but one large and respected health-tracking survey in the US found that the number of overweight or obese adults who succeeded in losing 10 per cent of their weight and keeping it off for at least a year was just one in six.

Hard to shake

People who attend weight-loss clinics that offer intensive support have somewhat better outcomes, but results are still disheartening. For instance, Taylor ran a programme based in Tyneside, north-east England, and Scotland that won recognition for helping people with diabetes lose enough weight to put their condition into remission. The programme offers a low-calorie shake-based diet for three months followed by monthly appointments for support in weight maintenance. Yet even here, just a third managed to keep their diabetes in remission for two years.

Disillusionment with mainstream dietary advice to cut out fat may be contributing to the growing popularity of controversial low-carb diets. Instead of avoiding fat and counting calories, these involve limiting starchy foods like bread and pasta.

Some low-carb weight-loss clinics have reported impressive short-term results, but as yet there is little data on how many people manage to keep up this type of diet and maintain their weight loss long term, perhaps because these diets haven't been popular for very long. It is a troubling gap in our knowledge if the aim is to avoid deaths from covid-19, since low-carb diets seem particularly helpful to people with diabetes and pre-diabetes, who are at an

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increased risk of covid-19, probably because starchy foods raise blood sugar.

Although it may seem extreme, the most effective way to lose weight is to undergo one of the various forms of weight-loss surgery, which shrink the stomach or redirect the gut. Such surgery makes it harder to overeat, and also means nutrients aren't absorbed as well. Increasing access to weight-loss surgery is one of the options Johnson is reportedly considering in response to the coronavirus.

Randomised trials have shown that such surgery does help people lose significant weight and that type 2 diabetes often goes into remission. But it is a major operation that carries additional risks to the normal concerns about surgery. For example, one study estimates that one in 10 people who have it develop some kind of addiction, such as alcoholism – as if people are transferring a previous "addiction" to food to something else once they can no longer eat the same quantities.

There were long waiting lists for weight-loss surgery in the UK before the pandemic hit. During lockdown, all non-urgent operations were stopped. While services are now resuming, that backlog has increased. It is hard to see how the UK's health service would be able to ramp up its provision of weight-loss surgery before this winter. "Is surgery for 30 per cent of the population really what we should be tilting at?" says Lean.

For Linia Patel, a dietitian and spokesperson for the British Dietetic Association, the only solution is to make societal changes to put the obesity epidemic into reverse. In public health parlance, we are living in an "obesogenic" environment, which makes it hard for people to resist eating more and expending less energy. "There should be far more emphasis on educating people to eat better and creating an environment that encourages them to do so," says Patel.

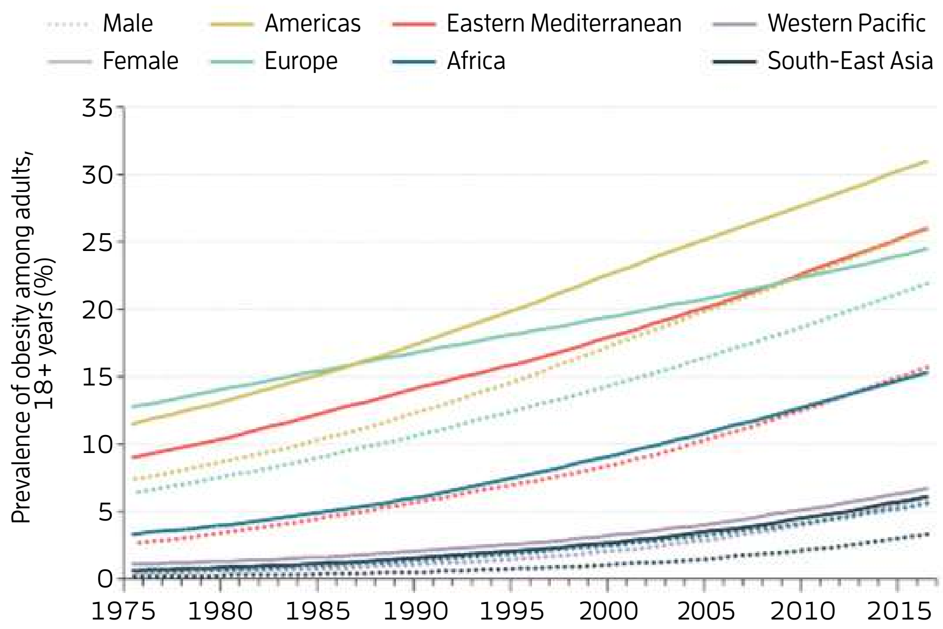
Yet it would take years for these sorts of changes to have any effect on the population's weight. And even here, there are few strategies proven to be effective at reducing levels of obesity.

Obesity mysteries

There are many differences between how people live their lives today and how they did before obesity rates started climbing, and we don't know which are the most important in causing obesity (see "Why are we getting heavier?", below).

One option would be to run state-funded long-term randomised trials to answer the question of whether we should discourage people from eating fat or carbohydrates. Advocates of each at least agree we should be trying to steer people away from highly processed foods, like fast food, ready meals and snacks, which tend to be high in fat, sugar and salt. "The food industry has been riding all over us," says Graham MacGregor at Queen Mary University of London, who co-authored the *BMJ* editorial.

Obesity has been rising around the world for more than 40 years



SOURCE: WORLD HEALTH ORGANIZATION

The question is how to do that steering. Countless school-based programmes that aim to teach children about exercise and healthy eating have failed to reduce obesity. Public health doctors have long called for tougher measures, like restricting junk food advertising and the number of fast food restaurants allowed near schools.

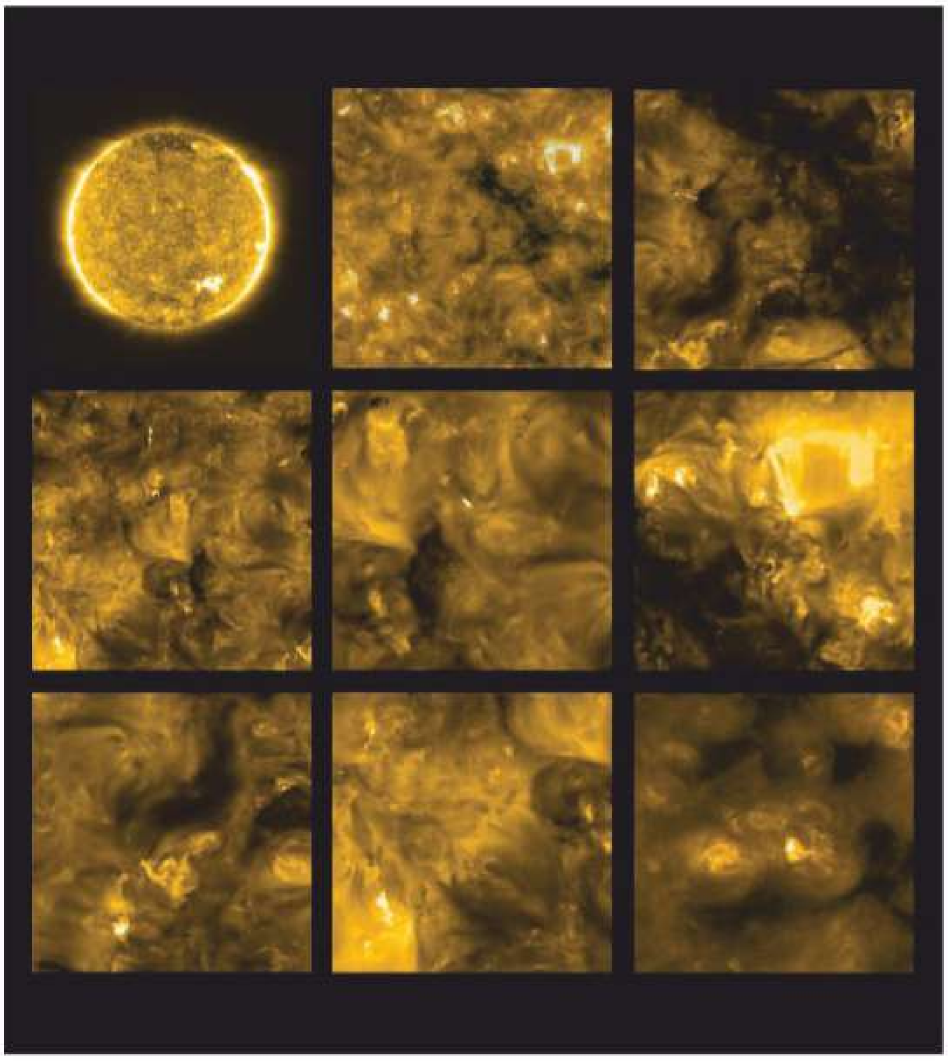
There are also calls to change the way food is taxed, so that highly processed food becomes more expensive. The UK government has just done the opposite, however, temporarily slashing taxes for restaurants in an effort to encourage consumer spending post-lockdown .

Ultimately, if Johnson's recent brush with death has made him rethink the importance of tackling obesity, that is probably a good thing for the UK's health that will bring benefits beyond the pandemic. But with many firms struggling as the country enters a deep recession, a cut in consumption to help people slim down may be hard to swallow. ■

Why are we getting heavier?

In nearly every country in the world, average weight is on the increase. This trend will be hard to reverse unless we know which aspects of life are responsible, and there are many suspects:

- **People are eating more. Average daily calorie intake has gone up in high-income countries, from around 3000 calories a day in the 1960s to 3400 in 2015, according to the World Health Organization.**
- **We may be eating the wrong sorts of food. For a long time, the chief villain was seen as too much fat in our diet. More recently, public health doctors have turned their attention to sugar.**
- **Highly processed food is often high in fat, sugar and salt. There has certainly been a major shift from eating home-cooked meals to snacks and fast food in many countries. But there is very little evidence from randomised trials to show that eating less processed foods leads to weight loss, apart from one study, which only involved 20 people for two weeks.**
- **People do less manual labour, walk less and spend more time sitting down in front of screens. Some believe this is the real explanation for rising obesity rates.**



SOLARORBITER/EUI TEAM (ESA & NASA); CSL, IAS, MPS, PMOD/WRC, ROB, UCL/MSSL

Solar system

Sun's extreme close-up reveals tiny solar flares

THE closest images ever taken of the sun have spotted miniature solar flares everywhere near its surface. They were captured by the Solar Orbiter probe developed by the European Space Agency (ESA).

Dubbed "campfires", these flares are up to a billion times smaller than the solar flares observable from Earth. Researchers think the campfires (yellowy white points in the eight close-up images, left) may be related to changes in the sun's magnetic field. But we don't know if they are tiny versions of solar flares or are made another way.

"Because of their multitude, they could contribute significantly to heating the solar corona," said ESA's Daniel Müller at a press event.

A joint mission between ESA and NASA, Solar Orbiter was launched on 10 February, carrying six instruments to image the sun and its surroundings. At its closest, the craft was 77 million kilometres from the sun – about half the distance between the sun and Earth.

The campfires were captured using an extreme ultraviolet imager on 15 June, when the craft reached its first perihelion, the point in its elliptical orbit closest to our star. "We've never been closer to the sun with a camera," said Müller.

However, other spacecraft have been closer. NASA's Parker Solar Probe was just 18.7 million kilometres away in January.

"Solar Orbiter is really the limit of where cameras can take images of the sun," said NASA's Holly Gilbert.

In the next mission phase, due to start late next year, the craft will get as close as 42 million kilometres from the sun's surface. **Donna Lu**

Technology

Artificial spider web keeps itself clean

THREADS of artificial spider silk are adhesive and shake off water, just like the real thing. Their creators hope that the work could one day help robots self-clean.

Won Jun Song at Seoul National University in South Korea and his colleagues made threads of artificial silk from a composite: a highly conductive hydrogel encapsulated in silicone rubber with a hydrophobic coating.

"Hydrogels have several outstanding features for spider webs," says Song. For instance, they are transparent and extremely stretchable.

The artificial threads are about 100 times thicker than typical spider silk and 250 times less rigid. Nevertheless, the webs can attract objects, like a leaf or a piece of glass, using electrostatic attraction. This makes them adhesive.

Most importantly, in a similar way to real spider webs, these artificial webs can shake off water and other contaminants to maintain their ability to attract objects. This is done by sending time-varying electric fields throughout the artificial silk, resulting in the web vigorously vibrating. After cleaning, the webs recover up to 98.7 per cent of their original adhesion force (*Science Robotics*, doi.org/gg4296).

The webs work for a few weeks, until the solvent in the gel dissolves. The researchers are currently working to increase this active lifespan.

Song says these webs could one day help robots self-clean. "Our approach could be used wherever cleanliness is critical for a device's reliable operation," he says.

"Spider webs are marvels of engineering in nature and by analysing them we can learn a lot about construction with robots," says Mirko Kovac at Imperial College London. **Jason Arunn Murugesu**

Environment

We have trampled on most of Antarctica

LESS than a third of Antarctica is still entirely pristine and free from direct human influence, according to an analysis that may bolster the case for greater environmental protection for the remote region.

To see if existing protections are sufficient given increasing human impact, Steven Chown at Monash University in Australia and his colleagues analysed 2.7 million records covering the past two centuries of human activity on Antarctica, including newly digitised books by explorers. Based on four accepted definitions of wilderness, they found that between 99.57 and 100 per cent of Antarctica could be considered to be such.

But narrowing the definition to areas never visited by humans meant that figure fell to about 32 per cent (*Nature*, doi.org/d35x). Such untouched areas are considered important as a baseline to assess our growing impact on the region's biodiversity, and because 12 nations have promised to protect them under the Antarctic Treaty, which promotes scientific cooperation in the region.

"If you trample through a moss bed, the mosses can take years to recover. If we really want to keep Antarctica pristine, which is what all the nations signed up to the treaty have said, are there any left for them to keep? It turns out not much," says Chown. **Adam Vaughan**

FRANS VAN HEERDEN/GETTY IMAGES

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Really brief

MARK STONE/UNIVERSITY OF WASHINGTON

Beetle cams stream live bug's eye view

Tiny cameras fixed to the backs of beetles can stream an hour of live footage to a smartphone app. They were tested on pinacate beetles (one pictured) and death-feigning beetles (*Science Robotics*, doi.org/gg4295).

Siberia feels the heat because of us

The record-breaking heatwave that has baked Siberia for the past six months was made at least 600 times more likely because of climate change. Researchers at the World Weather Attribution initiative say it is "effectively impossible" for it to have occurred without the warming driven by human activities.

Underground lasers clock Earth's spin

Huge lasers set 15 metres beneath Earth's surface are being used to measure the planet's spin with the most precision ever. The effects of Earth's motion slightly move mirrors reflecting the lasers, which scientists use to understand how the planet rotates (*Physical Review Letters*, doi.org/d4bz). This could help make GPS navigation more accurate.

Physics

Is this the lightest mirror of them all?

MIRRORS are usually created from the flat surfaces of metal or coated glass, but now they can be made from a few hundred atoms.

Jun Rui at the Max Planck Institute for Quantum Optics in Germany and his colleagues have made a mirror from a single layer of rubidium atoms. They believe it is the lightest mirror ever created.

To make it, the team first cooled several hundred atoms of the isotope rubidium-87 using a process known as laser cooling. "Imagine atoms as basketballs and the photons as ping-pong balls," says Rui. By directing enough photons at the rubidium, the tiny force of each one can collectively slow down the atoms.

A second stage called evaporative cooling reduced the atoms' temperature to around 10 nanokelvin. The researchers then applied a precise magnetic field in one direction to isolate a single layer of atoms (*Nature*, doi.org/gg45v9).

When atoms are randomly scattered in space they each interact with light independently, says Rui. But in the ordered lattice in the isolated layer, interactions between the atoms change their collective optical properties.

"Because of the close spacing in between the atoms, they will not emit light independently, but instead they can crosstalk with each other," says Rui. The result is a two-dimensional plane that reflects light shone on it.

Further exploration of the light-mediated interactions between atoms may lead to advances in quantum optics, says Rui. **DL**

Zoology

IMAGE SOURCE/ALAMY

Turtles often get hopelessly lost on long ocean journeys

SEA turtles are famed for their ability to navigate across open oceans. Now we have a better idea of how they do it, thanks to a study that reveals they often get lost.

"We were impressed that they are able to find small islands," says Nicole Esteban at Swansea University in the UK. "But their navigation is crude."

Green sea turtles spend most of their lives in one area, feeding on seagrass in shallow waters. Every few years, they migrate to breeding areas that can be thousands of kilometres away, spending a few months there before returning.

During four migrations, Esteban and her colleagues put GPS trackers on 33 female green sea turtles after they had nested on the Indian Ocean island of Diego Garcia. As the turtles can't feed in the open ocean, their likely aim is to head straight home.

Few managed it. Turtles returning to remote atolls and islands often missed their target and ended up swimming far further than needed.

The tracking suggests that they navigate long distances using a basic mental map and a crude sense of compass orientation. They set off in roughly the right direction and eventually realise if they have gone too far (*Current Biology*, doi.org/d36d). Michael Le Page

Vaccines

Secrets of a US civil war-era smallpox kit

STRAINS of viruses used for smallpox vaccines in the US during the civil war have been identified and their genomes reconstructed.

Smallpox, caused by the variola virus, killed about 30 per cent of those it infected. It was officially eradicated in 1980 after concerted global vaccination efforts.

Early protective practices against it involved infecting people with related viruses such as vaccinia to induce a milder case of disease that would inoculate them against variola. This was usually done by applying some infected pus or scabs to a cut in the skin.

While at McMaster University in Canada, Ana Duggan and her colleagues analysed genetic material collected from five US civil war-era vaccination kits that included tin boxes with scab material.

All five of the viruses identified were strains of vaccinia. None of the viral genetic material was intact, so it wasn't infectious.

The team then pieced together the viral fragments like a jigsaw puzzle, with the aid of a computer algorithm as well as the genetic sequence of an intact vaccinia virus as a reference (*Genome Biology*, doi.org/d4bx). **DL**

Welcome to our Signal Boost project – a weekly page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **Send a Cow**

Home-grown technology: how nature-based solutions can feed the world

Could the use of low-tech solutions help to revolutionise how we tackle food insecurity and the impacts of climate change?

In Sub-Saharan Africa, erratic weather patterns, parasitic striga weed and destructive insects like cereal stemborers and fall armyworm can completely decimate maize crops. Recent research from Send a Cow in Zambia has shown that 94% of farmers are struggling with these pests.

The common response would be pesticides or expensive interventions, which are unattainable for many, and can be devastating for ecosystems.

Yet there is a simple solution. Developed in East Africa by icipe and tested by the sustainable development charity, Send a Cow, climate-smart Push-Pull technology is an affordable nature-based solution providing effective, low-cost management of cereal stemborers, fall armyworm, striga weeds, aflatoxin and soil fertility[1].

Maize, a staple food for millions of people, is intercropped with a fodder legume desmodium, which produces volatile chemicals that repel the stemborer and fall armyworm moths (Push). The food crop is then surrounded by Napier or brachiaria grass, which attracts the stemborer moths (Pull) and encourages them to lay their eggs on the grass.

Both of the plants used are drought-tolerant, and able to withstand drier and hotter conditions associated with climate change, protecting people from food shortages. They are also perennial and produce high quality fodder crops all year round, increasing milk production[2].

Wise Mwale, a Send a Cow farmer in Zambia, established his Push-Pull plot in December 2019. He says: "I have noticed that [in] the areas where desmodium is well established there are fewer stemborers, fall armyworm and striga damaged crops compared to my conventional field adjacent - where nearly all the plants are damaged by these pests. This technology is working; [when] all the desmodium and the brachiaria are well established, I will have no challenges with these pests."

Push-Pull technology is an innovation in farming that is benefitting more than 1.5 million people in 250,000 farm households by significantly reducing hunger in 18 Sub-Saharan African countries[3].

At a time when coronavirus is preventing farmers from effectively producing and selling food crops, these low-cost, low-tech solutions are invaluable.

Battling with the effects of climate change, families need our help now to grow resilient and sustainable crops and mitigate the impending 'hunger pandemic' in sub-Saharan Africa.

Want to help?

Text **PUSHPULL to 70085** to donate £19 to Send a Cow. Your donation could cover the cost of a year's push-pull training for a family

[1] Cook et al. 2006; Khan et al. 2006; Khan et al. 2014; Khan et at 2018, Owuor et al. 2018

[2] Chepchirchir et al. 2018

[3] Pickett et al. 2019

Letters
Nowhere responded quickly enough to covid-19, not even New Zealand **p22**

Culture
A new adaptation of *Brave New World* has no lessons for today's world **p24**

Culture
What happens when a pandemic wipes out almost all of the world's men? **p25**

Aperture
Twilight skies viewed from an Australian cave and the Valley of the Moon **p28**

Graham Lawton is a staff writer at *New Scientist* and author of *This Book Could Save Your Life*. You can follow him @grahamlawton

Columnist

Life in the anthropause

The sudden cessation of global activity is showing us the changes we must make to rewild our planet, says **Graham Lawton**

WHEN I sat down at my kitchen table at the tail end of winter to write my first column under lockdown, I didn't think I would still be there come midsummer. That piece was about the health benefits of contact with nature and how to get them in a locked-down world.

I was reminded of this last week during a bike ride with my wife through the still-quiet streets of central London. We swung through St James's Park and stopped at the lake to admire the pelicans. The sun was shining, the water was clear and the big, ungainly birds were splendidly alien. It was a painful reminder of our decision to cancel a planned holiday to Greece, and with it the hope of seeing wild Dalmatian pelicans.

Thankfully, the country I am stuck in is becoming increasingly exotic. The pandemic has done little to slow Britain's accelerating rewilding movement. In the past few months, we have heard that European bison will soon be coming to Kent, that pine martens are making a comeback in England and that a pair of white storks at the Knepp Estate in West Sussex have successfully raised chicks – the first wild storks to breed in Britain for more than 500 years.

Two major rewilding projects have also been announced during lockdown. Solar power entrepreneur Jeremy Leggett has bought a 500-hectare estate in the Highlands of Scotland to restore nature there, and farmers in East Anglia are planning to turn over 250,000 hectares of intensively farmed agricultural land that could one day support lynx, beavers and, yes, pelicans.

Rewilding is largely a matter of humans getting out of the way and letting nature take charge. That, of course, has been happening in spades of late due to the sudden suspension of life as we know it – a period that a group of biologists has proposed calling the anthropause.

> "Scientists plan to use animal tracking from before, during and after the crisis to see how our activity affects them"

We know that the anthropause has benefited the environment in multiple ways, but its impact on wildlife isn't yet clear. There have been anecdotal reports of wild animals venturing into cities: jackals in Tel Aviv, pumas in Santiago, wild boar in Barcelona. But these are small and temporary incursions. What lessons can we learn as we come out of this period and try to build a better world?

To answer this question, conservation biologists have set up an international project called the COVID-19 Bio-Logging Initiative. Before the crisis, field biologists were already fitting wild animals with bio-loggers, small devices that track their movements and behaviour. The stage was inadvertently set to discover the effects of a global cessation of normal human activity. The scientists plan to analyse animal movement and distribution before, during and after the anthropause to determine exactly how human activity affects them, and then, once life can return to normal, to apply those lessons to the global rewilding movement.

"Nobody is asking for humans to stay in permanent lockdown, but we may discover that relatively minor changes to our lifestyles and transport networks can potentially have significant benefits for both ecosystems and humans," says Martin Wikelski at the Max Planck Institute of Animal Behavior in Radolfzell, Germany, one of the project's leaders. The human benefits include clearer knowledge of potentially dangerous human-wildlife interactions that increase the risk of viruses jumping species, according to the scientists.

I like the term anthropause. It captures the current hiatus in human domination of the planet, but also reminds us that the worst aspects of the Anthropocene could simply come roaring back. Rewilding is a quintessentially Anthropocene project, though it is often criticised for being more of an aesthetic than a scientific one. The pandemic presents a unique opportunity to put it on a more secure scientific footing. ▮

Graham's week

What I'm reading
Me and White Supremacy *by Layla Saad, a step-by-step guide to acknowledging and confronting your own complicity in the system of racial oppression.*

What I'm watching
Football, football and football.

What I'm working on
I'm still on the pandemic beat.

This column appears monthly. Up next week: Annalee Newitz

Editor's pick

Nowhere responded fast enough to covid-19

27 June, p 11

From Geoff Browne, Sydney, Australia

While New Zealand may claim some credit for the relatively early closure of its borders, it was still too slow. Nearly a month passed between the country's first known infection and lockdown. That isn't good enough.

Scientists had been warning of a covid-type pandemic for more than a decade. Borders should have been closed by the start of February at the latest. If countries had acted more courageously, most domestic economies would have largely continued to function. Now we see Western leaders trying to absolve themselves from responsibility for their own failures by blaming China.

Broadband for all will help us travel less

4 July, p 36

From Martin Pitt,
Leeds, UK

Corinne Le Quéré misses an important option in her advice to the UK government on how to use the economic stimulus required after the lockdown to encourage the shift to a net-zero society. As well as the electric cars and bikes that she mentions, lockdown has shown that choosing not to travel is possible. As such, some of the investment might be better used towards full-fibre broadband for all homes and businesses.

Many factors decide a nation's virus outcome

4 July, p 8

From Margaret Bridgman,
East Runton, Norfolk, UK

You report that Scotland could eliminate the coronavirus if it weren't for England. There are many reasons why the experience of covid-19 has differed regionally in the UK. To take just one example, overcrowding has been shown to be a big issue. Scotland has the lowest population density of the countries in the UK at about 70 people per square kilometre, whereas England's is about 430.

When you look at regional figures for each region, it is clear that rural areas have fared better than cities throughout the UK, irrespective of which government they fell under and which set of lockdown rules were in place.

As we get closer, so the queues will get shorter

Letters, 4 July

From Frank Boase,
Northchurch, Hertfordshire, UK

Peter Borrows wonders what will happen with the move to 1-metre social distancing as the lockdown is lifted. Here is one simple answer: the dole queues will get shorter.

Our laws might not apply in the next universe up

Letters, 4 July

From Richard Price,
Chipping Sodbury,
Gloucestershire, UK

It would be satisfying to be able to dismiss the idea that we are living in a simulation, as earlier letters have, using the argument that it would require unfeasible amounts of energy to run. Yet I am not entirely convinced. If our reality is a simulation, then the laws of physics that we perceive may well be part of that simulation too.

We can't know the laws that apply in the "next universe up", so the inhabitants of that universe could, for all we know, have ready access to sufficient energy to run the simulation – if energy is even a meaningful concept there.

From Hillary Shaw,
Newport, Shropshire, UK

The energy-related arguments that we don't live in a simulation created by an advanced civilisation hold true if the simulating entities are also in a three-dimensional existence.

However, what about higher dimensions? Up to 10 are postulated under superstring theory, for instance. Denizens of higher dimensions could be free of the energy constraints we face, so could have the resources required to simulate our 3D universe.

Tangled family tree may have other explanations

27 June, p 18

From Sylvia Barnard,
Albany, New York, US

You describe a Stone Age man buried in Ireland whose parents were either siblings or parent and child, and hypothesise that this might indicate the social sanctioning of incestuous marriages in this community.

Isn't it far more likely, if somewhat sadder, that this man's mother experienced sexual abuse by her father or brother, resulting in a baby that was then presumed to be the child of her husband? Such things are known to happen, but the social sanctioning of incest is extremely rare.

To stop a hurricane, just summon the US navy

Letters, 4 July

From Clive Saunders,
Stockport, Greater Manchester, UK

Michael Assuras suggests that hurricanes could be stopped by injecting cool air from an aircraft. When I was studying thunderstorm electrification, I was lucky enough to spend time at New Mexico Tech, where the institution's president – astrophysicist Stirling Colgate – talked to me about hurricane suppression.

Hurricanes gain energy from the warm oceans they pass over. His idea was to overturn the ocean in the path of the storm to bring up cooler water. He calculated that it was possible, but would need all of the US navy's ships to do it.

Fusion needs to try many different approaches

13 June, p 30

From David Pratt,
Bembridge, Isle of Wight, UK

I have watched the pursuit of fusion power for more than 50 years. However, the current approach begs a question. Half the world's population is funding one giant fusion experiment – ITER – that was designed decades ago. It relies on just one proposed fuel and is projected to cost about €20 billion and rising, with the aim to inspire a power plant that will generate electricity by 2050.

Rather than putting all our eggs in one basket, wouldn't it be better to fund 100 experiments with up to €100 million each instead?

Thanks for more than 60 years of inspiration

11 July, p 2

From John Spivey,
Thorverton, Devon, UK

Congratulations on *New Scientist* winning Consumer Magazine Brand of the Year at the Professional Publishers Association awards. I remember, while still at school, reading the issue in 1957 that had Sputnik on the cover printed on a blue ink background. Since then, I have read many issues, often for free after persuading physics students to subscribe while I was a teacher.

Want to get in touch?

Send letters to letters@newscientist.com; see terms at newscientist.com/letters

Letters sent to New Scientist, 25 Bedford Street, London WC2E 9ES will be delayed

For the record

- **The estimated number of people who have contracted coronavirus in the UK according to SeroTracker is 5.13 per cent (20 June, p 10).**
- **The source of the cholera outbreak that John Snow identified wasn't the water pump handle, but the water being pumped (6 June, p 54).**

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An updated vision of the future

A TV adaptation of *Brave New World* covers many of the same ideas as the book, but is somehow stripped of lessons for the present day, says **Simon Ings**

TV

Brave New World
UCP/Amblin
Available on Sky One (UK) date TBC and Peacock (US) from 15 July

THE 20th century produced two great British dystopias. The more famous one is *1984*, George Orwell's tale of a world unified into a handful of warring blocs run by dictators.

The other, *Brave New World*, was written in the space between world wars by the young satirist Aldous Huxley. It had started out as a send-up of H. G. Wells's utopian works – novels such as *Men Like Gods* (1923), for instance. Then Huxley visited the US, and what he made of society there – brash, colourful, shallow and self-obsessed – set the engines of his imagination speeding.

The book is Huxley's idea of what would happen if the 1930s were to run on forever. Embracing peace and order after the bloody chaos of the first world war, people have used technology to radically simplify their society. Humans are born in factories, designed to fit one of five predestined roles. Epsilons, plied with chemical treatments and deprived of oxygen before birth, perform menial functions. Alphas, meanwhile, run the world.

In *1984*, everyone is expected to obey the system; in *Brave New World*, everyone has too much at stake in the system to want to break it. Consumption is pleasurable, addictive and a duty. Want is a thing of the past and abstinence isn't an option. The family – that eternal thorn in the side of totalitarian states – has been discarded, and with it all intimacy and affection. In fact, no distinct human emotion has escaped this world's smiley-faced onslaught of "soma" (a recreational drug), consumerism and pornography. There is no jealousy here, no rage, no sadness.

The cracks only show if you aspire to better things. Yearn to be more than you already are, and you won't get very far. In creating a society without want, the Alphas have made a world without hope.

Huxley's dystopia has now made it to the small screen. Or the broad strokes have, at least. In the series, Alden Ehrenreich – best known for taking up the mantle of Han Solo in *Solo: A Star Wars story* – plays John. Labelled a "savage" for living outside the walls of the World State, he encounters the Alpha Bernard Marx (Harry Lloyd) and Lenina Crowne (Jessica Brown Findlay), his Beta pal.

STEVE SCHOFIELD/PEACOCK

The Alphas of *Brave New World* run society while Epsilons toil in factories

Bernard and Lenina are vacationing in Savage Lands, a theme park modelled a little too closely on *Westworld* in which people act out the supposedly sinful values of the old order for the entertainment of tourists. It is while they settle into their hotel room at the park that Lenina and Bernard suddenly realise they want to be alone together – a shockingly dirty idea in a world that has outlawed monogamy and marriage – and that "it could be our wedding night".

"In Huxley's book, characters were given a hard choice between freedom and happiness"

"We're savages," gasps Lenina, as it dawns on the two what they actually want. It is a scene so highly charged and sympathetically played that you only wish the rest of the show had lived up to it. The problem with *Brave New World* is that it is trying to be Huxley's future in some scenes and trying to be our future in others. The two do not mix well.

Some of Huxley's ideas about the future loom over us still. The potential eugenic applications of CRISPR gene editing keep many a medical ethicist awake at night. In other respects, however, Huxley's dystopia has been superseded by new threats. Artificial intelligence is changing our relationship with expertise, so who needs human Alphas? At the other end of the social scale, Epsilons would struggle to find anything to do in today's automated factories.

Squeezed by our technology into middle-ranking roles (in Huxley's book, we would be Betas and Gammas), we aren't nearly as homogenous and pliable as Huxley imagined we would be. Information technology has facilitated, rather than dampened, our innate tribalism. The difference between the haves and have-nots in our society is infocentric rather than genetic.

In Huxley's book, the lands left for those deemed savages featured an unreconstructed humanity full of violence and sorrow. Characters were given a hard choice between freedom and happiness. None of that toughness makes it to the screen. At least, not yet.

The TV series is a weirdly weightless offering: a dystopia without lessons for the present day. It is as consumable and addictive as a capsule of soma, but no more nutritious. ■

A woman's world

When a pandemic kills almost all the men on Earth, the women are made monstrous with power, finds **Sally Adee**

Book

Afterland

Lauren Beukes

Michael Joseph (UK) and Mullholland Books (US)

AARON MCCOY/GETTY IMAGES

In *Afterland*, a mother tries to flee the US with her son after almost all males die

IF ALL the human cells in your body were to suddenly dematerialise, your outline would briefly persist, in all its exquisite detail, in the form of the billions of bacteria and viruses that colonise your every nook and cranny, still suspended in the shape of the frame your body provided.

Something analogous happens in Lauren Beukes's novel *Afterland*, available in July worldwide and in September in the UK. Over about two years, a pandemic kills nearly every man in the world, leaving its patriarchal systems staffed exclusively by women. Cole, the mother of one of the precious few surviving boys, needs to get him out of the US and back to their home in South Africa. Her sister, meanwhile, wants to sell him. This gives the novel its structure and speed: it is a deceptively simple heist caper, with Cole on the run across the US from both her sister and the Department for the Protection of Males.

The organisation is charged with imprisoning the few males that remain, probing them to find whatever biological quirk has spared them from the plague and using that knowledge to find a vaccine for the virus. Its aim of jump-starting society "back to normal" will be uncomfortably familiar as we too languish in a pandemic limbo between the Before and the After, hoping for our own vaccine. The misguided waiting game in the novel results in a few temporary accommodations to reality: straight women negotiate awkward first dates with one another, while fake baby bumps become the hottest fashion accessory.

So who gets to maintain civilisation now, and do women run a better society than men? This is where the book shines as one of the best thought experiments of its kind, in which Beukes has stitched together the surprise matriarchy of *The Power*, the millenarian despair of *Children of Men* and the deeply intelligent questions of Ursula Le Guin's *The Left Hand of Darkness*.

The Power – in which women develop the ability to give electric shocks, ending their status as the "weaker sex" once and for all – concludes that women are just as bad as men when in ultimate control.

> "There is no guarantee that the once-oppressed will wield power any more judiciously than their oppressors"

Beukes's take is more ambiguous. Like Le Guin, she seems to conclude that it doesn't much matter if it is women or men in charge of society, as it is the structures themselves that turn us into monsters. "You have to be bigger and meaner as a woman to claim your turf," Cole's sister tells herself, negotiating her nephew's kidnapping on behalf of the widow of the kingpin she used to work for. The widow has slid into his place, just as easily as the thugs around her have shifted from being vicious beauty queens to vicious enforcers. The Sisters of Sorrow, the religious community in which Cole and her son take refuge, somehow figures out how to make Christianity even more violently misogynistic in a world without men.

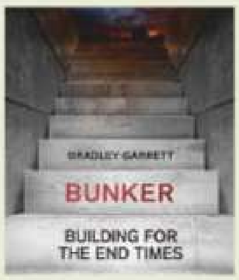
Yet it isn't all nihilism. Beukes seeds the book with hopeful rumours of matriarchal societies that have sprung up in other countries. There are never many details beyond the promise, like mirages just over the horizon. "They say the matriarchal societies have been a lot better about getting rid of the homosexuality laws," promises an email from a friend trying to help them escape across the Atlantic. It is a promise of a better body politic.

Afterland is that rare creature, a ripping tale that neither shies away from big questions nor interesting answers. What happens when the powerless get power? There is no guarantee that the previously oppressed will wield it any more judiciously than those who oppressed them. It isn't about the individuals. It is about the society they need to maintain. ▮

Don't miss

Watch

The Umbrella Academy returns to Netflix for a second season on 31 July, scattering the streaming service's most dysfunctional superpowered siblings across Dallas, Texas – and each to a different historical era.



Read

Bunker: Building for the end times by explorer and geographer Bradley Garrett is an uncomfortably timely book that looks at the worldwide trend of "prepping" for social and environmental collapse.

Watch

Proxima, Alice Winocour's much-anticipated astronaut drama grounded by the covid-19 lockdown, is among the films showing at Picturehouse cinemas when they reopen in the UK on 31 July. Eva Green and Matt Dillon star.

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Albert Einstein

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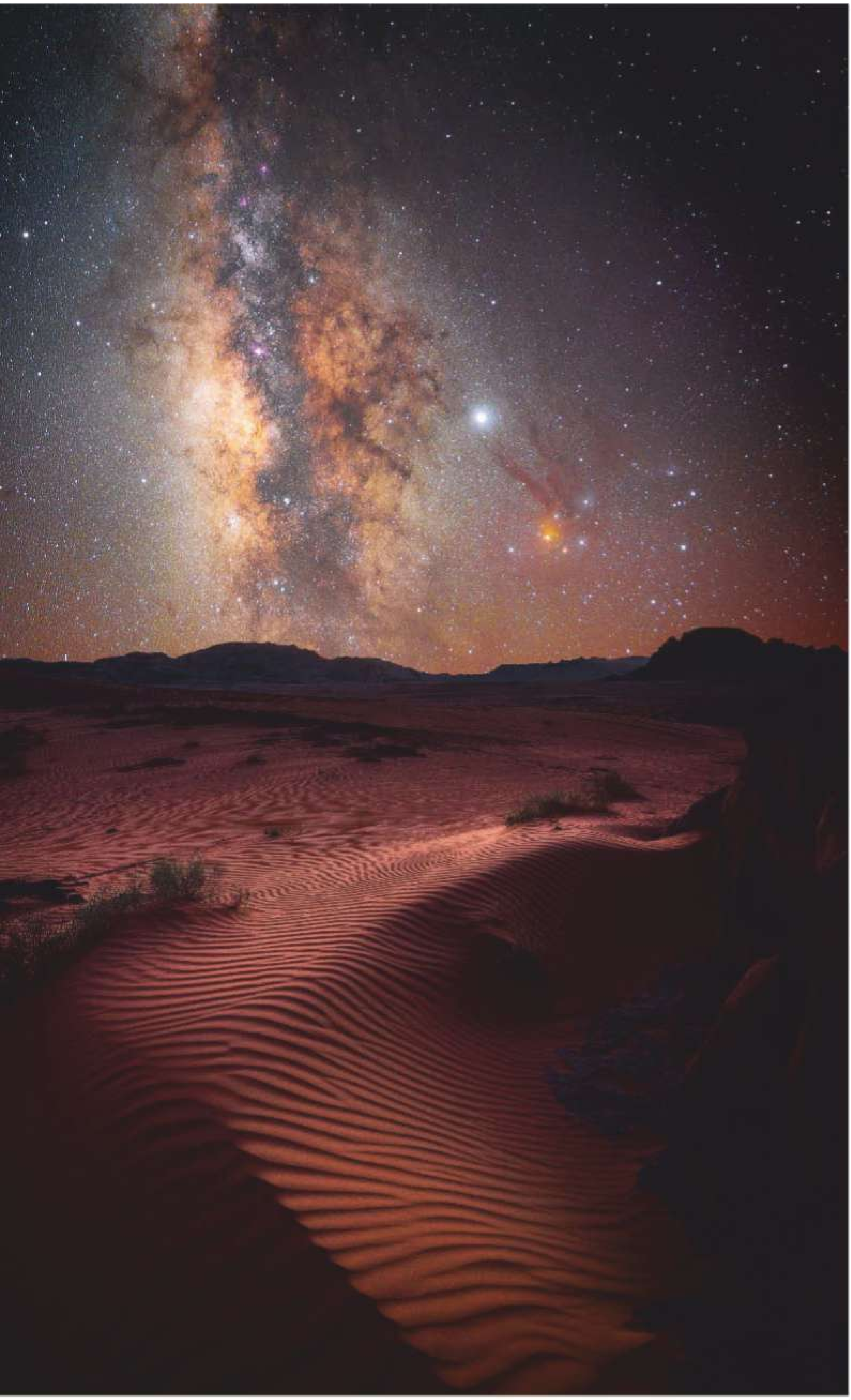

Out of this world

Photographers Stefan Liebermann, Marcin Zajac

THESE ethereal images showcase the beauty and spectacle of our universe. They are among the thousands of photos shortlisted for this year's Insight Investment Astronomy Photographer of the Year competition, a global contest organised by the Royal Observatory Greenwich, UK.

Galactic Portal (far left) was taken by Polish photographer Marcin Zajac during a visit to the coastal town of Kiama in New South Wales, Australia. Zajac waited in a small cave for the splendour of the Milky Way to emerge, and was surprised to glimpse Jupiter among the constellations, which can be seen in the shot as the brightest spot to the left of the central rock stack.

To its right is Desert Magic by Stefan Liebermann from Germany, featuring the Wadi Rum desert valley in Jordan, also known as the Valley of the Moon. Its otherworldly sandstone and granite rock formations, arching mountains and canyons are highly reminiscent of a Martian landscape.

The winners of the competition will be announced in an online ceremony on 10 September.

Gege Li

The dark matter in your diet

There's a giant hole in our knowledge of what we are eating. It's time to hunt for some answers, finds **Graham Lawton**

TODAY I searched my kitchen cupboards for dark matter, and found it in a packet of Korean instant noodles. The food label ran to 38 ingredients, many of them additives. But it also listed some real foods, including soy, chilli, sesame, shrimp, cabbage, seaweed, mushroom, anchovy and cuttlefish. And also the one I was looking for, garlic.

To be clear, I'm not suggesting that garlic contains actual dark matter, the 85 per cent or so of material in the universe that physicists say is there but cannot observe directly. But it does contain what has been called "nutritional dark matter": the thousands and thousands of compounds that are in food but which, until recently, were totally unknown, and which may be affecting our health. Given that eating is one of the big human universals, that's a mind-boggling oversight.

"Our understanding of how diet affects health is limited to 150 key nutritional components," says Albert-László Barabási at Harvard Medical School, who coined the term nutritional dark matter. "But these represent only a small fraction of the biochemicals present in our food." It is time, he says, for nutritionists to go dark-matter hunting, to massively expand our knowledge of what is on our plate and its impact on us.

The idea that food is a rich and complex mix of biochemicals is hardly news. Even the well-known macronutrients – proteins, carbohydrates and fats – are hugely diverse. There's also a vast supporting cast of micronutrients: minerals, vitamins and other biochemicals, many of which are only present in minuscule quantities, but which can still have profound health effects.

The official source of information on this complex biochemical soup is the National Nutrient Database for Standard Reference, maintained by the US Department of Agriculture (USDA). It contains information on the composition of hundreds of thousands of foods, broken down into 188 different nutritional components.

A lot to digest

Search for "garlic", for example, and the database serves up 58,055 foodstuffs that contain it, ranging from whole, raw garlic to processed foods such as instant noodle soup. The entry for raw garlic lists 67 macro- and micronutrients, some quantified down to micrograms per 100 grams, or concentrations of less than 0.00001 per cent. That may seem detailed, but is far from comprehensive. For example, it omits some of the quintessential flavour compounds in garlic, such as alliin.

This is a general problem across the USDA database, says Barabási. It tracks only common nutritional components in many foods, and so omits many rarer ones. The USDA began to fill this gap in 2003 by adding 38 flavonoids – plant compounds associated with a lower risk of cardiovascular disease – to its existing panel of 150 components. But that is as far as it went.

Around 10 years ago, an international team of researchers decided to compile a more comprehensive database after trying and failing to get detailed information on the composition of various foods. "We could only track down lists of a few dozen compounds, not the hundreds or thousands we expected," says David Wishart at the University of Alberta, Canada, one of the project's founders. "The fact that there was so little known about the micronutrients in commonly consumed foods really bothered us." So they trawled the literature and filled in other blanks through their own chemical analyses in the lab.

The result is a massive database called FooDB, which Wishart says now holds information on about 70,000 nutritional compounds – nearly 400 times more than the USDA database. For example, the USDA lists 67 compounds in raw garlic, but FooDB has 2306.

By that reckoning, with the USDA as your guide, 99.5 per cent of the components in food are a mystery. Even FooDB is incomplete. Of the 2306 compounds in garlic it lists, for example, only 146 have been quantified, meaning that more than 2000 others are known to be present but at unknown concentrations. This problem is writ large across the whole of FooDB, with a total of about 85 per cent of nutritional components as-yet unquantified.

In other words, when it comes to the make-up of the food we eat, we have only assessed the tip of the iceberg lettuce

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(which, incidentally, the USDA says contains 11 compounds, while FooDB lists more than 4000). "We've severely underestimated the complexity of food," says Tim Spector at King's College London, author of the forthcoming book *Spoon-Fed: Why almost everything we've been told about food is wrong*. "Food is incredibly complicated: the chemicals are complicated; when it enters our guts, it interacts with microbes which make it into other chemicals, which also have complicated effects on our body. Because we've focused on macronutrients and calories, the whole field has been dumbed down." Barabási's research is "opening people's eyes" to the true complexity of food, he says.

Why complicate things further? Because dietary dark matter may be affecting our health, both for good and ill. "Having more detailed information of what compounds are in food certainly would be helpful to nutrition researchers," says Larry Parnell at the Jean Mayer USDA Human Nutrition Research Center on Aging at Tufts University in Massachusetts.

Dark nutrients

Right now, it is hard to say exactly how helpful, because so much remains uncharacterised. "The health implications are largely unknown," says Barabási. But there is good reason to believe that some of the neglected compounds have meaningful effects (see "Garlic crush", page 34). "Certainly, some of these dark nutrients are quite important for human health," says Wishart.

The idea hasn't gone down well in some established nutrition circles. There is an urgent need to identify confounding factors in nutritional epidemiology, says Mike Gilbey at University College Dublin, Ireland, but gaps in our knowledge of nutrients isn't one of them. "Nutrients are fully known, and they alone account for almost all of the impact that diet has on non-communicable disease. There is no dark matter."

Another obvious objection to the claim that understanding the dark matter is important for health is that most of the compounds occur in tiny quantities. But, says Barabási, that raises a misconception. "The concentrations of mapped and unmapped nutrients span about nine orders of magnitude, yet concentration is not always the factor: vitamin E comes at micrograms per 100 gram intake of food, yet its absence has adverse health effects. So it is not true that low concentration chemicals do not have an effect on health."

To start to understand the scale of our ignorance, Barabási and his colleagues consulted another database – the Comparative Toxicogenomics Database, an inventory of how thousands of chemicals interact with our bodies.

First, they looked at the 67 "official" components of garlic, and found that 37 were already known to be linked to human health and disease. Then they did the same for the 2306 compounds in garlic listed in FooDB, and discovered a further 574 with potential health effects.

These vast tracts of uncharted complexity could be the reason why nutrition science so often produces inconsistent and irreproducible results, says Barabási. This is familiar to anyone who tries to keep up with flip-flopping nutrition advice. One week red wine is bad for you, the next week it isn't. Ditto red meat, eggs, saturated fat and many more. Without a complete picture of the nutritional composition of food, you can't be sure you are comparing the right things.

This is also true of individual micronutrients. "Consider beta-carotene," says Barabási. "It tends to be positively associated with heart disease, according to epidemiological studies, but studies adding beta-carotene to the diet do not show health benefits. One potential reason is that beta-carotene never comes alone in plants; about 400 molecules are always present with it. So epidemiology may be detecting the health implications of some other molecule."

Another probable cause is the effect of the microbiome on dark nutrients, says Wishart. "Most dark nutrients are chemically transformed by your gut bacteria. That's probably why studies on the benefits of different foods give relatively ambiguous results. We don't properly control for the variation in gut microflora, or our

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"It would be foolish to dismiss 99.5 per cent of what we eat as unimportant"

innate metabolism, which means different people get different doses of metabolites from their food."

All of which suggests there is a food mountain to climb. But there is a way forward. There are many parallels, says Barabási, between our understanding of nutrition and health and our knowledge of genetic epidemiology before the human genome was sequenced.

In those pre-genome days, only around 1.4 per cent of human DNA – the chunk that codes for proteins – was considered important, and the other 98.6 per cent was considered junk. The idea of sequencing the whole genome was often dismissed as a waste of time and resources, says Barabási. And yet we now know that about two-thirds of sequences linked to disease are in those "junk" regions, many of which are stretches of DNA that control gene expression.

That doesn't imply that the majority of associations between diet and health will be found in nutritional dark matter. But it would be foolish to dismiss 99.5 per cent of the compounds we eat as unimportant, says Barabási.

There is only one answer, he says: to fully map the dark matter. His team and others are already working on it. That inevitably means having to analyse food the old fashioned way, with slow and laborious lab techniques such as mass spectrometry and nuclear magnetic resonance. To make this a tractable problem, these methods may have to be re-engineered to make them faster, he says.

Diet and disease

But there are other avenues. Barabási and his team, who are physical scientists rather than nutritionists, specialise in using big data and the science of complex networks to probe, among other things, the genetic origin of human disease. This is what led them to nutrition. "Genetic data can only explain about 5 to 20 per cent of disease causation," he says. "We are interested in finding the rest, and food is the next big opportunity to fill the gap. Also, big data has not yet touched nutrition."

To test the potential of such approaches, Barabási and his colleagues created a text-mining tool to dredge the scientific literature for scraps of information about the constituents of food. This unearthed some of the missing concentration figures for garlic – for example, it found one for diallyl disulphide, another pungent flavour molecule with possible health benefits. It also discovered a further 96 components of garlic that aren't even listed in FooDB. Doing the same for cocoa, the researchers found 238 novel compounds. This suggests there is a good deal of information out there already which has yet to be pulled into the databases.

But garlic and cocoa are just two of about 2000 natural ingredients people consume. "We are currently expanding to multiple foods including milk, apple and basil," says Giulia Menichetti of the Network Science Institute at Northeastern University in Massachusetts, who co-developed the text-analysis tool, called FoodMine. "We aim to cover the most common staple foods, to have a good grasp of the chemical complexity of our diet."

As if all that wasn't hard enough, there is the added complication that cooking transforms chemical components into others, sometimes with health implications. When sugars and amino acids react at high temperatures, the result is new molecules that make roasted and grilled food ›

Garlic crush

Researchers are hunting down tens of thousands of untracked "dark nutrients" in food (see main story), but why do we need to know about what we eat in such fine detail? To get an idea, let's talk about steak and garlic. Gut bacteria break down a substance in red meat to produce a compound called trimethylamine (TMA). This is then absorbed and transported to the liver, which converts it into trimethylamine N-oxide (TMAO). High levels of TMAO in the bloodstream are linked to significantly higher death rates from coronary heart disease. But one of garlic's flavour molecules, allicin, is known to inhibit TMA production. This may be one reason why the garlic-rich Mediterranean diet protects against heart attacks. Allicin has also been reported to have anticancer properties, while another component of garlic, luteolin, which isn't in the standard database of food compounds produced by the US Department of Agriculture, also seems to protect against cardiovascular disease.

MANOA/GETTY IMAGES

Raw garlic is now known to contain more than 2000 compounds, some of which can boost our health

delicious, but the reactions also produce the compound acrylamide, which is a probable human carcinogen. Cooking and processing nutritional dark matter could produce similar, but unknown, toxins, says Barabási.

Our metabolisms get to work on nutrients, too, adding yet more complexity. "Food compounds are often chemically transformed by various enzymes in the mouth, stomach and the intestine," says Wishart. "As a result, many of the dark nutrients are biotransformed into a variety of smaller, stranger metabolites that then recirculate back into the blood and other tissues. These biotransformed dark nutrients are the ones that really have the more significant health effects."

There are also the myriad chemicals added during food processing. What happens to them when they encounter our metabolisms and microbiomes is unknown.

And if just identifying the compounds in food is a challenge, working out how they interact with human biology is an even bigger one. "Ultimately, we need to connect all the food molecules to their molecular effects in the human cell," says Barabási. That, too, requires laborious lab work.

Once again, new computational techniques can do the heavy lifting. Over at the USDA, for example, a team led by Parnell is developing a way of using artificial intelligence to predict how dietary dark matter acts once we have eaten it.

Its system, called PhyteByte, cross-references FooDB with another database called ChEMBL. This is an inventory of 1.9 million compounds known to have some sort of biological effect, maintained by the European Bioinformatics Institute near Cambridge, UK.

For a pilot project, the team wanted to see whether the tool could figure out which compounds in FooDB might activate a protein that is involved in fat and glucose metabolism, and therefore could be of interest in treating diabetes.

When the AI was set loose to scour FooDB for compounds that are also likely to interact with the protein, it got 10 hits. Two of these compounds were already known to act on the protein. But the other eight weren't, including sesamin from sesame seeds, a flavone called irigenin from lima beans and compounds from tea, herbs and spices. It will take time, says Parnell, but it should be possible to eventually assess the biological activity of all 70,000 compounds in FooDB.

Ultimately, says Barabási, the goal is to build a complete picture of the interplay between nutrients and human health. That is a colossal undertaking that requires yet more data on individuals' genomes, microbiomes and other factors, but it is the only way for us to truly understand the complexities of human nutrition and health. "So much to do," he says. "But we're making progress."

The Korean noodles are still in my kitchen cupboard, and I don't think I will be eating them any time soon. I never kidded myself that they were a health food. But I don't want to go over to the nutritional dark side. ▮

Graham Lawton is a *New Scientist* feature writer

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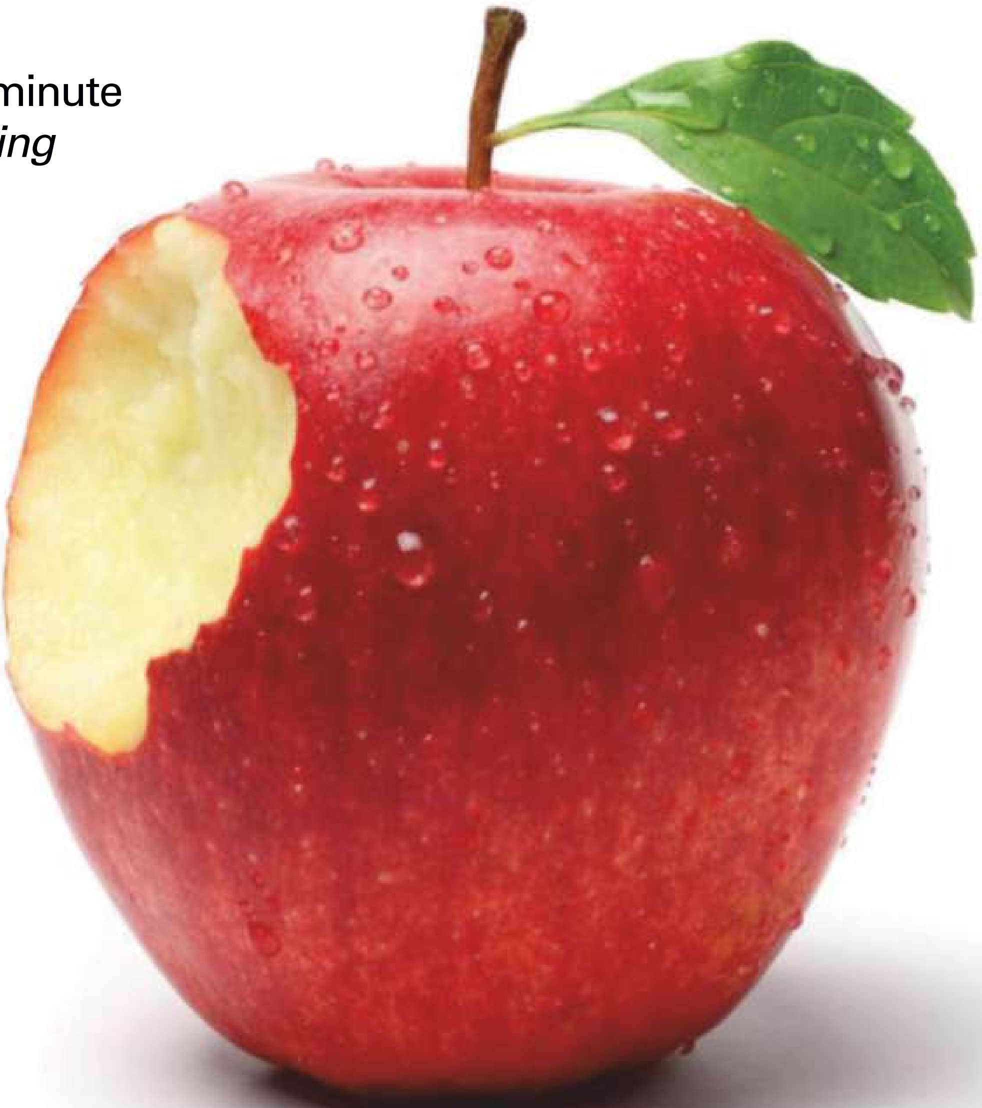

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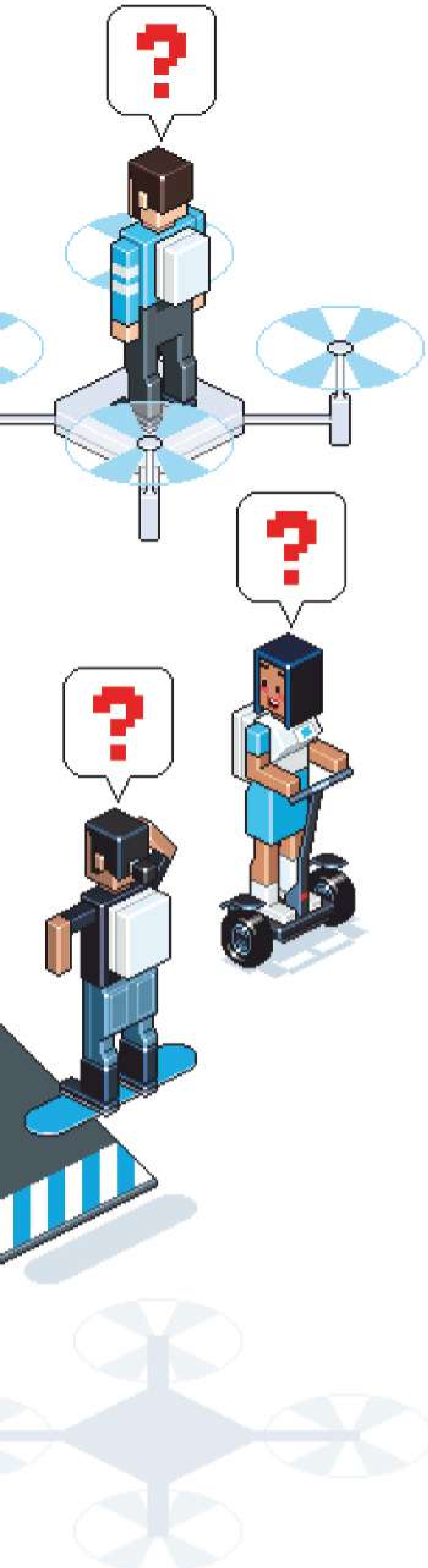


Analogue comeback

Old-school technology may shape the future of digital computing, finds **Anna Demming**

AMID an epic haul of jewels and statues rescued from an ancient Greek shipwreck, it was a lump of corroded wood and bronze that would capture the world's imagination. Pulled from the Mediterranean Sea in 1901, the Antikythera mechanism was an astonishingly sophisticated 2000-year-old computer. The size of a shoebox, sporting chunky bronze gears rimmed with hundreds of triangular teeth, it was built to chart the paths of celestial bodies and was capable of addition, multiplication, subtraction and division – all by cranking a handle.

Nearly half a century would pass before its significance became apparent. By that time, the world had developed a new breed of calculators: the digital computers we still use today. Powered by electricity rather than a hand crank, they were a huge step forward and have proved fast and powerful enough to keep the modern world afloat.

But digital computers aren't always the best tool for the job. Much of the mathematics used at the frontiers of modern science, for example, translates awkwardly into digital technology, where certain equations are cumbersome to solve. New approaches are increasingly sought after in the design of artificial intelligence, too, where digital computers struggle to mimic the complex processes of the human brain. As such, the latest hardware is often too expensive and inefficient to use in this area.

TOTTO RENNA

Mechanical devices are unlikely to be the answer. Even so, to better meet today's challenges, researchers at the cutting edge of computer development are looking to analogue techniques that have more in common with the Antikythera mechanism than today's conventional computers. To save computing's future, we may need a blast from the past.

As the name suggests, analogue computers can provide a physical analogue of the system they are describing. In a device like the Antikythera mechanism that is made up of a set of rotating cogs, for example, the positions of certain cogs represent the locations of the sun and moon. You can always tell where those objects are just by looking at the cogs.

By contrast, a digital machine has no such exact mappings. Instead, it converts all information to numbers, such as the coordinates of the sun and moon, and performs calculations on those numbers › to chart their change. By operating on the numbers independently of how the physical equipment itself works, digital computing can be hugely versatile. Swapping between different problems just means setting up a different set of mathematical commands, rather than re-engineering cogs or their equivalent for each type of calculation.

A little bit better

A key characteristic of digital computers is the use of binary digits – also known as bits – that represent all the processed or stored data as a string of 0s and 1s. In the first digital computers, information was stored and fed in via punch cards with holes representing 0s and solid card representing 1s. For the calculation itself, the computers read the information and translate it onto circuits equipped with transistors capable of switching between two states – that is, routing a current one way or another. Processing the data then involves following a program that flips the right set of switches at each stage of the calculation.

One drawback of storing data in the form of binary digits is that the values for variables are no longer continuous. Whereas a pointer on a cog can rotate seamlessly through everything between the numbers 4 and 5, for instance, a basic digital computer might jump from 4.1 to 4.2 without being able to represent the values in between. Adding more bits can make the gaps between numbers ever smaller, but having to make jumps of some size is inevitable.

This doesn't necessarily mean a drop in accuracy. Think of a digital stopwatch versus an analogue one: although a precise measurement of the angle of the second hand could, in theory, allow you to read off infinitely small units of time, in reality the eye won't read a simple dial with the same accuracy that digital figures can drill down to.

The first programmable, general-purpose digital computer was the Electronic Numerical Integrator and Computer (ENIAC), introduced in 1946. It was the size of a room and took days to program, but it was significantly more powerful than any computer that had come before. Analogue approaches kept up for a while, but they were little more than a quaint memory by the 1980s.

Yet even today the world isn't as digital as it seems. "The physical world is analogue," says Yannis Tsividis at Columbia University in New York. Analogue technology is still all around us. The electromagnetic radio signals that our smartphones use to communicate with each other, for instance, are analogue, requiring analogue-to-digital converters to allow the phone's digital electronics to process them.

Analogue isn't just useful for shifting data from one place to another. There are situations where these technologies are proving superior to digital ones for processing data, too. One key area concerns the kinds of equations used for everything from modelling the effects of hormone levels in the body to understanding particle behaviour. These differential and integral

LOUISA GOULIAMAKI/AFP VIA GETTY IMAGES

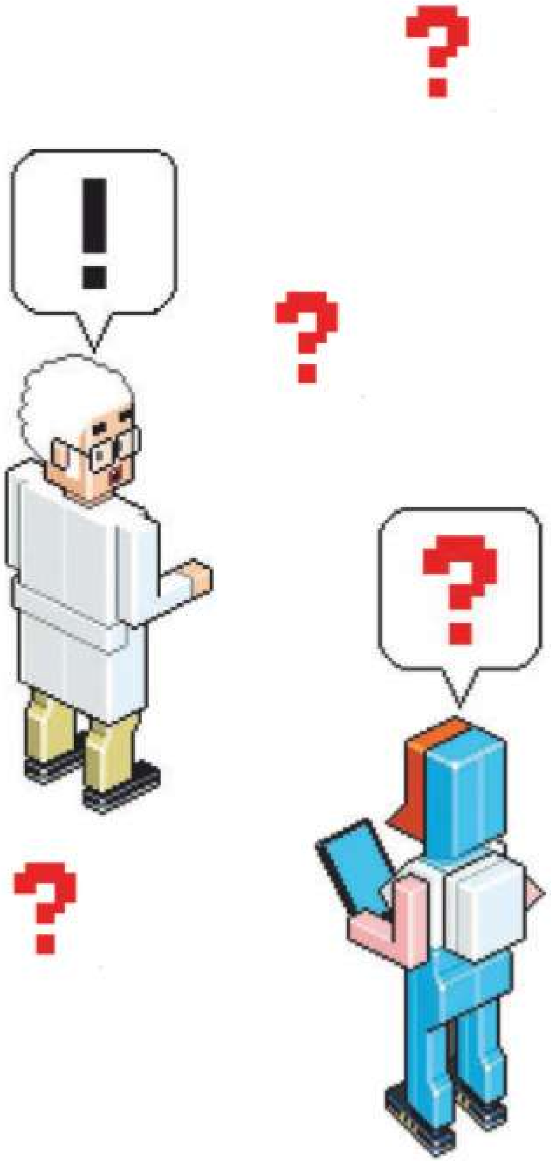
The Antikythera mechanism, an analogue computer from ancient Greece (above); IBM's Blue Gene digital supercomputer (below)

EVERETT COLLECTION HISTORICAL/ALAMY

equations are mathematical expressions in which quantities are related in terms of their rate of change rather than just their values. The digital approach to tackling them involves calculating and storing the value of each point along a function relating two variables, and then performing calculations on those stored values. An analogue computer, by contrast, would be able to work on the whole function at once.

One way of doing this is to harness the mathematics that governs electrical circuits themselves. Quantities like electric current, charge and capacitance are related by rates of change in their values. This means they fit differential equations, allowing electrical circuits to serve as analogues for all other systems governed by such mathematical expressions. That is why Tsividis and his colleagues have used these kinds of circuit elements to develop all-electrical analogue chips.

Unlike the analogue computers of the 1940s and 1950s, with their punch cards and primitive wiring, these chips benefit from all the same advances in semiconductor research that have made digital computers smaller and faster. These new analogue chips can connect to each other as well as to conventional digital computers, and – most importantly – can solve certain problems faster and more efficiently than their digital counterparts. For example, multiplying two eight-digit binary values digitally would take about 3000 transistors, but an analogue computer would need a maximum of eight. "People did not seem to have considered analogue computing in the context of modern technology," says Tsividis. "We did, and things looked very promising."



"It would take about 3000 transistors to do the calculation digitally. An analogue computer would need eight"

It isn't only electronics that could be useful for analogue computing. Researchers are now turning to beams of light, not least because of the possibility of superfast data transfer. Optical technology offers other benefits as well. When you put objects in the way of light, for example, you get effects that provide a physical analogue for a wide range of phenomena. These range from simple dispersion – which can also be used to describe the behaviour of electrons – to solitons, lone travelling waves that share mathematical descriptions with earthquakes and stock market behaviour.

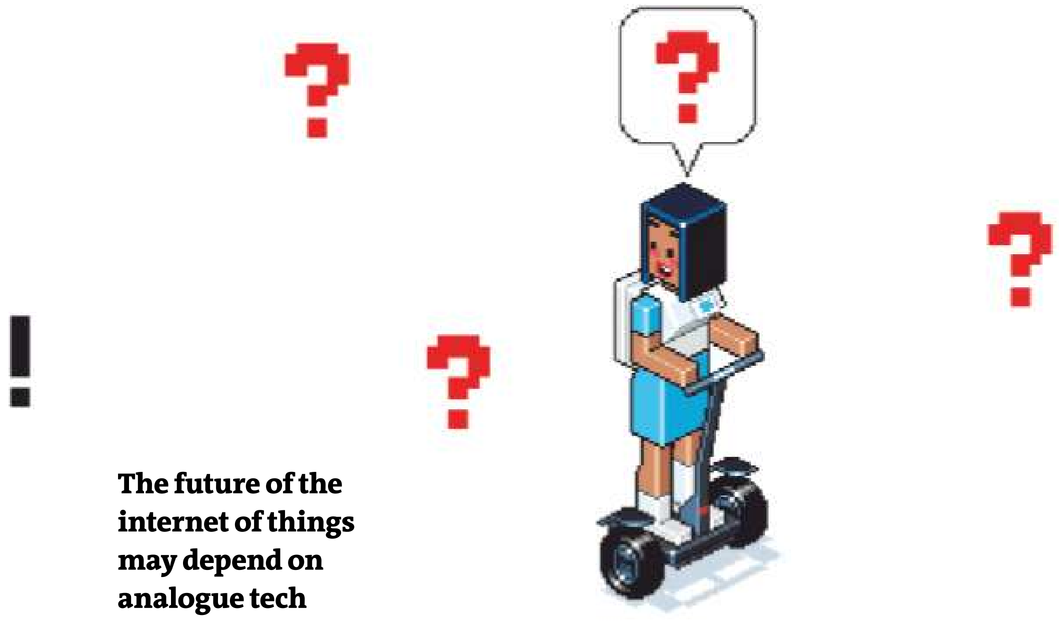
Nader Engheta at the University of Pennsylvania and his colleagues have shown that fast optical analogue computing is possible using interactions between light and matter. They have used a complex structure known as a metamaterial to affect the path of light in such a way that it can solve integral equations. Their prototype, which looks like a Swiss cheese about half a metre or so across, is designed to work on the long wavelengths of microwave radiation. Future iterations could do so on optical or shorter wavelength radiation, allowing the structure to be a thousand times smaller and faster.

Brain training

One particularly influential backer of analogue computing has been the US Defense Advanced Research Projects Agency (DARPA), which invests in innovative technology. In 2016, DARPA sought designs for analogue or hybrid analogue/digital devices that could provide the capabilities of a supercomputer in a desktop device. Some of the most promising ideas to come out of that scheme revolved around electronic devices called memristors.

Any time an electric current flows through a circuit, it encounters resistance. In a memristor, that resistance changes in response to previous use, and the altered resistance state is retained when the circuit is off, meaning it has memory. This is useful for computing as power-free data storage, but also interests scientists working on neuromorphic computing, in which electronic circuits are used to mimic the workings of a brain.

The strength of the connections, or synapses, between the brain's neurons grows stronger as more signals pass through them and weakens if signals become rare, giving them learning functions akin to muscle memory. This continuously varying connectivity is awkward to replicate with ›



The future of the internet of things may depend on analogue tech

MARKO GEBER/GETTY IMAGES

digital technology, which needs currents to be in one state or another – on or off. Memristors are therefore seen as an attractive basis for neuromorphic computing.

Not everyone is convinced. "I see some marginal benefits of analogue circuits for neuromorphic implementations, but these benefits come with very high costs that are generally not worth paying," says Mike Davies, director of Intel's Neuromorphic Computing Lab. "Digital design methods optimise the key figures of merit that matter – accuracy, power, speed and chip cost – in ways that analogue approaches can't match."

Few would argue that digital generally wins hands down in terms of precision. What seems to still be open to debate is how much that matters. "These [analogue] devices and systems emulate real neural-processing systems," says Giacomo Indiveri at the Swiss Federal Institute of Technology in Zurich. "As such, they are noisy, imprecise and unreliable." Indiveri is an advocate for combining analogue with digital technologies to get the best from both. His view is that what biological neural-processing systems lack in precision, they make up for with sophisticated feedback mechanisms for adaptation, learning and plasticity. Designed correctly, neuromorphic devices and algorithms could also benefit from this trade-off.

That could have huge implications for the power and speed of computing. The tech giant IBM's Blue Gene was one of the most powerful supercomputers in the world in 2011, yet it still struggled to simulate the billions of neurons and synapses in the brain of a cat, all while guzzling through enough energy to run a thousand domestic homes.

Memristor devices could not only be more compact, but stand a chance of matching the brain's energy efficiency, delivering the same results on a thousandth of the power. As ever more objects, from smart fridges to children's toys, become equipped with computational power as part of the much-touted internet of things, Indiveri sees analogue-embracing hybrid technologies as a way to power these devices more efficiently.

> "Hybrid digital-analogue devices could not only be more compact, but stand a chance of matching the brain's energy efficiency"

He isn't alone. IBM has teams dedicated to analogue innovation for AI. One of the firm's researchers, Hsinyu Tsai, points out that such analogue devices are already finding use in everyday technology, such as the specialised chips that let you rouse your phone with a spoken command. "Analogue approaches fit especially well with today's AI applications, where models consist of a large number of computations, yet require only limited numerical precision," says Tsai.

It was two thousand years ago that the Antikythera mechanism sank to the sea floor. After all this time, perhaps we are only just coming to understand the true power of its analogue legacy. ■

Anna Demming is a freelance writer based in Bristol, UK

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Feeling the heat

Friederike Otto calculates the extent to which extreme weather can be blamed on global warming. The science could soon be used as evidence in court, she tells Adam Vaughan

ROCIO MONTOYA

THE bush fires that engulfed parts of Australia earlier this year were nothing short of apocalyptic. More recently, a record-breaking heatwave has hit Siberia, causing a thaw in the permafrost that contributed to one of Russia's worst ever oil spills. But were these disasters caused by climate change?

For a long time, scientists have said that we can't pin any single extreme weather event on our greenhouse gas emissions. That is still true, but in recent years, researchers have become far better at estimating how much more probable any given "natural" disaster was made by human-caused global warming.

This work is called extreme event attribution, and it involves comparisons between real observations of weather events and computer simulations of a world with and without the roughly 1°C hike in temperatures caused by humanity so far. Run the simulations thousands of times and you can calculate the odds of the event occurring in both scenarios. So you can say, for example, that the drought conditions that were responsible for the Australian bush fires were made at least 30 per cent more likely by climate change. Or that human-induced global warming made the rise in temperatures that have been seen in Siberia over the past few months at least 600 times more likely.

Friederike Otto at the University of Oxford, who led the team behind the rapid-response studies that made both of these estimations, is at the vanguard of the field. As co-founder of the World Weather Attribution project, she has been pivotal in recent work that has significantly sped up the process.

Attribution already occurs in a matter of weeks, but soon it could happen within days. And Otto thinks that a change of this sort could have a profound effect on efforts to strong-arm governments into tougher action on carbon emissions. What's more, attribution could even soon be used as evidence in legal cases in which people affected by extreme weather make claims for damages against governments or fossil fuel companies.

Adam Vaughan: How do you describe your job to people?

Friederike Otto: I'm trying to answer the question of whether, and to what extent, man-made climate change altered the likelihood and intensity of recent extreme weather events. The data-processing aspect of that is a very small part of my work. Most of my day-to-day work is thinking about the most appropriate data sources to use for these kinds of studies, or which models should be used, or how we can test the models better to see whether they are able to reliably simulate the weather event.

What developments have moved your field along? Is the progress purely down to better data and more computing power?

Actually, the big advance has been that we have realised how important it is to understand what question you're asking. You can define a heatwave as unusually high summer temperatures over three months, and you will find that climate change made it orders of magnitude more likely. But you

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can also define a heatwave as a very local thing, as the heat stress that affects the human body, which depends not just on temperature, but humidity too. In that case, you will find that climate change maybe doubles the likelihood.

If you are interested in mortality because of a heatwave, you will frame it differently to someone interested in agriculturally relevant summer temperatures. What we do have convergence on is methodology: there is agreement that we need to use at least two different models for every calculation to understand the errors they can produce.

> "Wherever you live, there is damage from extreme weather that you wouldn't have had without climate change"

In a warmer world, we can expect more extreme events like the drought that preceded the Australian bush fires. Is that going to make attribution easier or harder?
The main difficulty is in whether we have models that really represent the processes behind extreme weather events. For example, do we have models that are able to simulate strong enough hurricanes in the first place? That doesn't really change with increasing temperatures. On the other hand, the signal of human-caused climate change gets bigger with increasing temperatures, so it is getting easier to disentangle it from the noise.

What has attribution achieved so far, and what is next for this science?
I think the impact so far is really in raising awareness of the fact that climate change is happening right now, and that wherever you live in the world, there are damages from extreme events that you would not have had without climate change.

On what comes next, one of the things I've learned relatively recently is that it would be better not just to say the weather today has changed because of climate change, but also to say something about what that means in the future. So now we have a world that is 1°C warmer than in pre-industrial times. How would weather patterns change in a 2°C-warmer world?

We do not only want to understand what climate change means right now, but what we will need to adapt to. Which are the types of events and areas of the world where climate change is a real game changer, so that we have to completely alter how we deal with the impacts of such events? With limited resources, it is important to understand where to best focus them.

I understand you are also looking at whether attribution could be used as evidence in legal cases in which people claim for damages against companies or governments.
The legal community is realising that this is now a possibility. In many older climate litigation cases, the reason for not admitting evidence that humanity's greenhouse gas emissions are to blame for extreme weather events and the damage they cause, was that you can't say the chain of causality is complete. But I've been working with lawyers to see whether you can use attribution studies in courts in a meaningful way. We are not far off seeing successful cases using that kind of argument – in one, two or three years.

The way society sees climate change has changed too, and judges are a part of society. It would be very strange if that shift in public perception would not also filter through to the courts; that understanding that climate change and the damages it causes are real.

US ARMY PHOTO/ALAMY

You have said before that the results of attribution studies are quite conservative. Is that still true? And does it really matter, given that they still reveal the link between extreme weather and climate change?
At the moment, especially with heatwaves, we can only give a lower bound: we can say OK, climate change made it at least 30 per cent more likely. It would be better to be able to also at least quantify the upper bound. So that is a problem. If you want to quantify damages, and if you want to understand the extent of the adaptation measures you are going to need to put in place, such as higher flood defences, then you need more detail.

We seem to be good at doing attribution studies for events in the developed world, but not so much in poorer countries. Is that a problem?
We absolutely need to redress the balance. On the one hand, it would help us to understand what climate change means globally. But more than that, if we really want to adapt to climate change, understanding the extreme cold snaps in the US, for example, might not be the most important thing. It might be more important to understand the droughts we see in East Africa. At the moment, there is

A resident of Houston, Texas, is rescued after hurricane Harvey hit the city in 2016

no evidence that climate change is causing migration from eastern Africa, but it is a question we must address. We can't just ignore parts of the world and think it doesn't affect the rest of us.

With respect to responsibility, I believe Europe should not complain about migration completely independent of climate change. But from a causality point of view, attribution studies do allow for a better understanding of the consequences of our political decisions, and that does beg questions of responsibility too.

You grew up outside the city of Kiel in northern Germany, and your mother was a teacher and your father a biologist. How did your upbringing shape you?

My parents were hippies. They were the '68 generation, protesting on the streets for social reforms and sexual freedom. It was very much not a conservative household. They lived in the middle of nowhere because they found that very romantic. Mainly, it meant a relatively lonely childhood. And I just read. I still live half my life in novels. Above all, though, what my parents gave me was a tendency to question norms and rules.

Germany is often held up as a world leader on climate change because of renewables, but may take until 2038 to phase out coal, while the UK currently plans to do so by 2024. How well do you think Germany is doing in tackling carbon emissions compared with the UK?

It is very good at talking but very bad at doing. I think Germany is an example of how not to do it because it implies it is this green leader, but German politics is still to a large degree dictated by the car industry. There are a lot of things very wrong with UK politics, but on climate change, the way it has approached this has been better.

Still, it's not great. Its words still need to be followed up with legislation. But it is encouraging that the UK government did announce a net-zero emissions target very early, it has science-based adaptation plans and it has the Committee on Climate Change, which is bringing science directly into government.

What do you think the covid-19 crisis means for the fight against climate change?

What I'm worried about is people thinking we have to do the same things we're doing to tackle coronavirus to tackle climate change. It could reinforce this fear that climate action would completely disrupt the economy. What we need to do for climate change is very, very different. The changes have to be long term, so you don't shut down the economy, you just change things – and there are a lot of winners and a lot of things that are better in that scenario. In that sense, it's an opportunity. In our plans for economic recovery after coronavirus, we have to think about climate change.

How optimistic are you that we are going to get a handle on reducing emissions globally?

I'm very optimistic we will have a world we can still live in. One of the main reasons for hope is what has happened in the past two years in terms of how the conversation has changed on climate change. For most people in my generation, and definitely the people in the younger generations, climate change is something that is important and there's no question that it's something that needs to be tackled. ▮

Adam Vaughan is chief reporter at *New Scientist*. Follow him @adamvaughan_uk

A revolution in the offing

We've learned so much about the origin and evolution of the universe over the past century, cosmologist **Dan Hooper** told a recent *New Scientist* online event – but there are signs our theories might soon have to radically change

From beginning... to end
Cosmologist Katie Mack will be exploring our theories about the universe's ultimate fate in an online event on 13 August.
Details on all events at newscientist.com/events

THROUGHOUT all of human history, people have looked up at the night sky and wondered about the universe and how it came to be. But in one respect, we're very different from our ancestors: we more or less understand what we're looking at.

Take an image from the Hubble Ultra Deep Field, for example. We know the blotches of light on it are not stars, but entire galaxies similar to own Milky Way. And because it takes time for light to travel through space, we're not seeing what these galaxies look like today, but rather what they were like over 13 billion years ago, a few hundred million years after the big bang.

A little over a century ago, scientists didn't have the faintest understanding of our universe's distant past, and they certainly knew nothing about its origin. We didn't have the tools even to conceptualise questions about how the universe might change or evolve. All of that changed with Albert Einstein. With his general theory of relativity, he how showed how space isn't static and unchanging. It can be curved; it can warp and deform; it can expand and contract.

In 1929, Edwin Hubble observed that the universe is in fact changing. Every galaxy is receding from us; every two points in space are getting farther apart from each other as time advances. The universe is expanding.

If the universe were smaller in the past, and we know how much matter and energy it contains, we can deduce that its matter and energy density must once have been higher. Billions of years ago, it must have been in a denser, hotter state, and expanded into the cooler world we see today. That is the basic premise of the big bang theory.

According to this picture, wind back to some 380,000 years after the big bang, and we reach a point when the universe had first cooled enough for atoms to form. It suddenly became transparent to radiation, dumping an enormous amount of light into the cosmos that's been propagating throughout space ever since. Today we see this light as the cosmic microwave background, a sea of radiation cooled to 2.7 degrees above absolute zero. Its existence gives us confidence that we understand the universe and its evolution from this point right up to the present day.

Going back even further, to the first seconds and minutes after the big bang, we encounter a time when the universe was about a billion degrees, 100 times as hot as the sun's core, and functioning as a giant nuclear fusion reactor. We can predict how much deuterium, tritium, helium, lithium and beryllium we think should have been made in this era – and again, the predictions agree with what we observe today.

Going back even further, we can't make direct observations, but we can recreate the conditions of the early universe using particle accelerators such as the Large Hadron Collider near Geneva, Switzerland. The LHC accelerates protons to about 99.999997 per cent of the speed of light and collides them head on at a rate of about 600 million times every second, exploiting Einstein's famous equation $E = mc^2$ to convert as much of the energy released as we possibly can into mass. This allows us to create a variety of exotic forms of matter that are very rare in our universe now, but were extremely common in the incredibly hot first trillionth of a second after the big bang.

> **"You might think we know a lot about the universe's first fraction of a second That just isn't true"**

From all I'm saying here, you might now be under the impression that we know a lot, and with a great deal of confidence, about the universe's first small fraction of a second. But sadly, that just isn't true. I'm going now to talk about four puzzles or problems that cosmologists have discovered or revealed over the last few decades, which all point to something missing in our understanding. To solve them, I increasingly think we're going to have to radically rethink what we think we know about the universe's very early history.

The first puzzle has to do with the simple fact that atoms exist. Everything we know from particle accelerators and other such experiments tells us that, for every kind of matter that exists in the universe, there exists a kind of equal and opposite mirror version, antimatter. When you create more matter, you create an equal amount of antimatter; when you destroy one of them, you destroy the other along with it. So whatever created the universe's matter should have created an equal amount of antimatter. As the universe expanded and cooled in its first fraction of a second, we calculate that matter and antimatter should have destroyed each other almost entirely. There should be no atoms, no molecules, no stars, no galaxies, no planets and no life.

Our second puzzle has to do with matter, too, but not the kind that consists of atoms. It is "dark" matter that doesn't appreciably reflect, radiate or absorb light. Since the 1970s, astronomers have been measuring how fast stars in other galaxies are moving in their orbits. They've consistently found that stars in galactic outskirts are moving too fast for the amount of visible material the galaxies contain. Nearly all galaxies seem to contain a small amount of visible material, compactly located in the centre of a larger "halo" of dark matter.

Making some assumptions about how dark matter must work, we can create computer models to find out how it would have impacted the universe's evolution. When we do that, we find near-perfect agreement with the distribution of galaxies and clusters of galaxies we see in the

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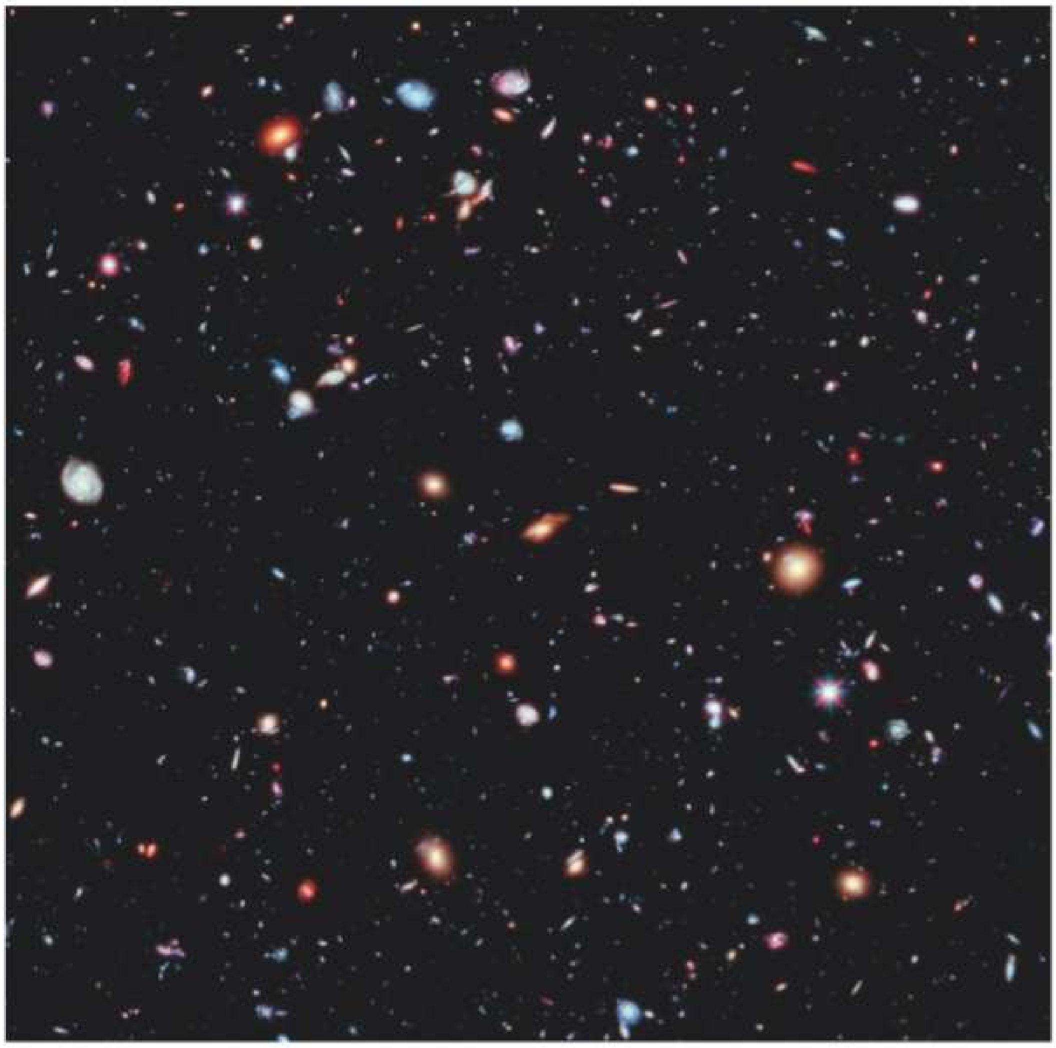
STUDIOM1/ISTOCK PHOTO

The Hubble Ultra Deep Field pictures the cosmos over 13 billion years ago



NASA; ESA; G. ILLINGWORTH, D. MAGEE, AND P. OESCH, UNIVERSITY OF CALIFORNIA, SANTA CRUZ; R. BOUWENS, LEIDEN UNIVERSITY; AND THE HUDF09 TEAM

> **“We're going to have to radically rethink the universe's early history”**

universe today. With dark matter, we can explain it; without dark matter, we can’t.

If you’d asked me what the dark matter consists of maybe 10 or 15 years ago, I would have given you a very confident-sounding answer about how it was probably made up of “WIMPs”, short for weakly interacting massive particles. We thought we knew how to detect these particles, so we built impressive, super-sensitive detectors for them deep underground in places like the Gran Sasso laboratory in Italy – but we still haven’t observed any dark matter particles.

Our third puzzle has to do with how fast our universe has been expanding over time. General relativity gives you basically three possibilities. You can have a universe that expands for a while, reaches a maximum size and then starts to contract; you can have a universe that expands forever, but with its expansion slowing down; or you can live on the boundary between those two cases, and have a universe that gets bigger for a while and then approaches a maximum size.

For decades, cosmologists set out to try to measure which of these three cases describes our universe. And the answer turned out to be: none of the above. Instead of slowing down, in the past few billion years our universe’s expansion rate has been getting faster. The universe is accelerating.

Within the context of Einstein's theory, the only way to explain this behaviour is to posit that space itself contains a fixed density of “dark energy”. Unlike matter and other forms of radiation, dark energy doesn't get diluted as space expands, so it plays an increasingly important role, ultimately driving the universe to speed up its expansion rate.

The fourth and final puzzle has to do with the extremely early universe, maybe something like 10^{-32} seconds after the big bang. If you take the big bang theory as it was envisioned in the 1960s and 1970s, it is very hard to explain why our universe is so uniform, and also what we call geometrically flat – basically, it follows the rules of conventional Euclidean geometry. There’s no reason why either of these things should be.

In the 1980s, physicists began to posit an explanation: cosmic inflation. In its very early stages, our universe expanded in explosive fashion, growing exponentially by a factor of something like 10^{75} in volume over a very, very brief period of time, smoothing itself out as it did so. The best thing is that inflation made some very specific predictions about patterns of light we would observe in the cosmic microwave background – and we have observed them.

One thing that I find really compelling – or exciting, anyway – about inflation, is it takes even a very tiny amount of space, and it rapidly turns it into a multitude of universes: a multiverse. Quantum physics says that different patches of that space will stop inflating at different times, essentially creating something like our universe. But this doesn't happen just once; in fact it happens without limit. Inflation seems to lead inevitably to the conclusion that there should be an infinite or nearly infinite number of universes in existence, some maybe a lot like ours, some very different.

That gives us a lot to ponder about the possible varieties of existence we might find throughout the multiverse. But all these puzzles give us also a lot of reason to doubt that we understand the whole story of the first fraction of a second of the universe.

It brings to mind a question I’m fond of asking my colleagues: what would it have been like to be a physicist in 1904? The reason I pick 1904 is because it’s when physicists seem to have had the most confidence that they really understood the universe. Newtonian physics had reigned supreme for over two centuries. It had been applied to problem after problem, and it just kept working. There was every reason to think that Newtonian physics could just be applied to anything – heat, electricity, magnetism – if we just thought long and hard enough about it.

But back then there were also a few loose ends; a few problems and puzzles that hadn't been resolved. One was the way light seemed always to travel at the same unvarying speed, no matter what frame of reference you were in. Another was how Mercury's orbit didn't fit what was predicted by Newtonian physics. People had posited that maybe there was an additional planet out there called Vulcan that had perturbed Mercury's orbit, but no one had ever been able to see it.

A third puzzle was that no one knew how the sun got its energy. Geologists had already shown us that Earth and the sun were billions of years old. Even if the mass of the sun were made of some fuel like gasoline or coal, it should have run out of energy a long ago. And then a fourth puzzle: Newtonian physics couldn't explain the inner workings of atoms. It predicted they were unstable, and couldn't say why particular atoms gave off special patterns of light, what we call spectral lines.

The resolution to these problems was not an incremental change of Newtonian physics. It came with a revolution ushered in by Albert Einstein and people who followed his work. In 1905, Einstein introduced his theory of relativity that explained the uniform speed of light, and would eventually explain the Mercury's orbit. When you combined relativity with what we learned about quantum physics, we could explain the nuclear fusion that powers the sun, and begin to understand the inner workings of the atom. The revolution that came forth in 1905 tore down Newtonian physics and left something else, something that would have been unimaginable in 1904, in its place.

Right now as a cosmologist, I wonder if 2020 is the 1904 of cosmology. I hope so, because that means in 2021, or some other short time down the road, we are going to have a revolution that will be very exciting to live through. Of course, I could be wrong. But that's what I'm hoping for, that's what I'm excited about – and all these puzzles make me think that it's at least a little more likely. ■

Dan Hooper is head of the theoretical astrophysics group at Fermilab in Illinois and author of *At the Edge of Time: Exploring the Mysteries of Our Universe's First Seconds*. This is an edited version of a talk he gave at a *New Scientist* online event on 9 July 2020

Your big bang questions answered

Dan Hooper also took questions from audience members after his talk. Here's a selection of the best

WHAT COLOUR WAS THE BIG BANG?

That's a great question. As it turns out, it depends exactly how close to the big bang you're asking about. When the first atoms were forming a few hundred thousand years after the big bang, the whole universe was filled with a 3000-degree plasma of electrons and protons and light. At 3000 degrees, things would have looked bright red throughout space. But as you go further back things would have got hotter and hotter. They would have looked bluer and bluer and eventually white. Ultimately, it would cease to be light that you could even see with your eye – it would look increasingly ultraviolet.

HOW DO WE KNOW THE UNIVERSE IS 13.8 BILLION YEARS OLD?

There are a lot of different ways we measure this, from its expansion history and from detailed temperature patterns we observe in the cosmic microwave background, for example. If you'd asked cosmologists this 20 years ago, you would have got a wide variety of answers: some might have said 8 billion, some 20 billion. But over time, we've measured things better and better, and there's total agreement. I'm not saying it couldn't be 13.85 or 13.75, but within a small margin of error it's right around 13.8.

IF DARK MATTER ISN'T WIMPS, WHAT DO YOU THINK IT IS MADE OF?

I have a pretty open mind right now. Just to be clear, I still think it could be WIMPs, but if it's not, we have a bunch of ideas that are all appealing. One is particles called axions which are very, very light, and were produced through kind of exotic mechanisms in the early universe. They would solve a bunch of problems. I also work a lot on "hidden sector" theories, where there are a variety of forms of matter and energy that all interact among themselves, but don't directly interact with any of the forms of matter that we know or can observe in particle accelerators. But there are hundreds of viable dark matter candidates. Our goal is ideally to discover which one or ones are correct, but if we can't do that, at least rule out as many contenders as we possibly can.

WHAT HAPPENED BEFORE THE BIG BANG?

That's a kind of tricky one to answer. If you take the classic version of the big bang, before people started to talk about cosmic inflation, then people like Stephen Hawking and Roger Penrose and others worked out that if you run those equations of general relativity backwards, you eventually reach what we call a space-time singularity, at which point space and time really came into existence. So you can't talk about what happened before that, any more than you can talk about what's north of the North Pole.

But if inflation happened, those singularity theorems are kind of thrown out the window. Inflation could have gone on forever, expanding exponentially without limits, popping off pocket universes, one after the other, for all time.

But I think we should be pretty humble about what might have set off inflation. We don't know. Anyone who gives you a very competent sounding answer to this question at this point in our intellectual history probably should put some more caveats on their answer.

New Scientist events

Want to see Dan Hooper's full talk?

Sign up for the event on-demand, including exclusive access to additional *New Scientist* content at newscientist.com/events

HOW TO EXTRACT IRON FROM YOUR BREAKFAST CEREAL

Breakfast cereals often claim to be fortified with iron. Well, are they?

They are and, more amazingly, if you have a magnet you can extract it too! So ponder the ingredients list on your packet of cornflakes while you are munching breakfast, and then set about removing one of them . . .

WHAT DO I NEED?

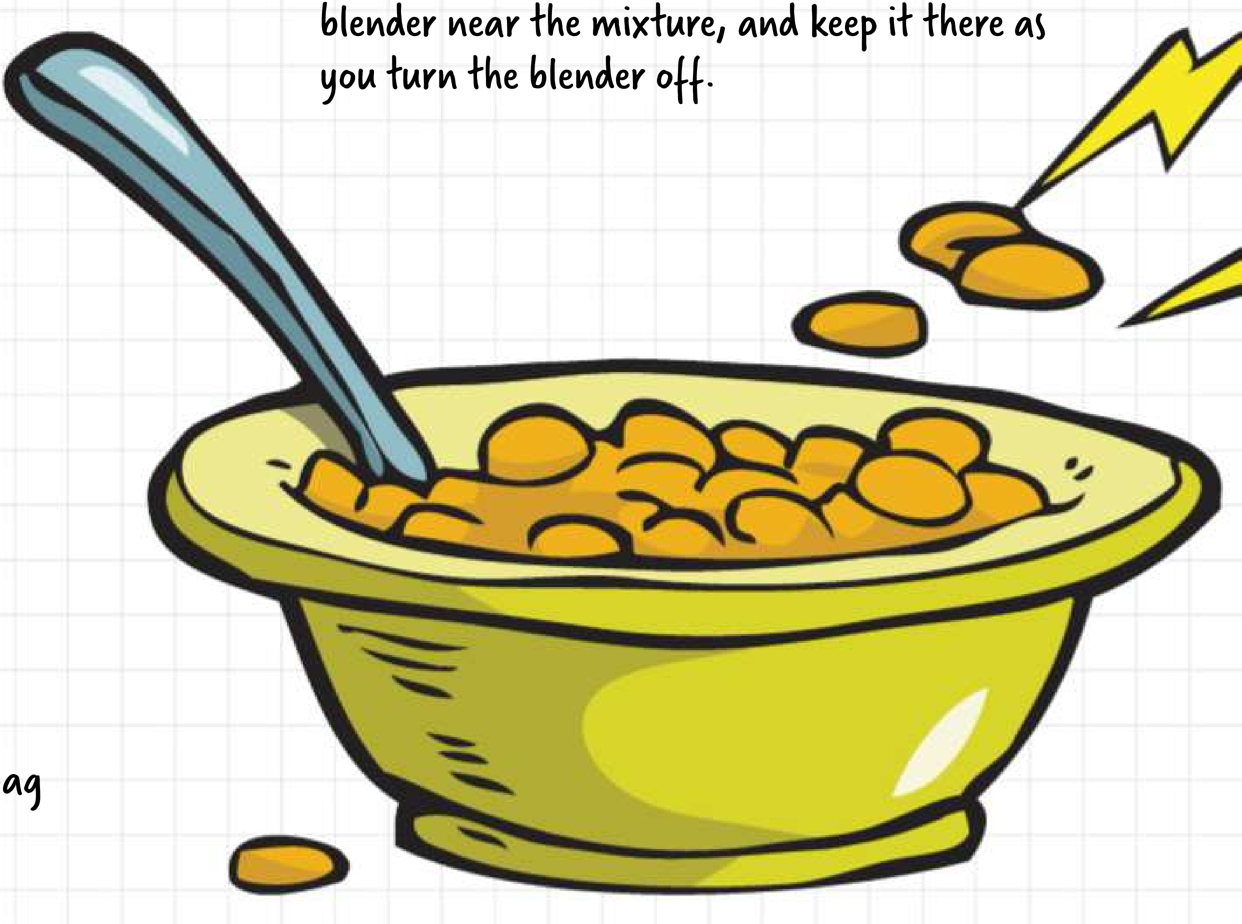
- breakfast cereal fortified with iron (cornflakes work, but check on the side of the packet to see what the iron content is – the higher, the better)
- a plastic cup
- a spoon or pestle to crush the cereal (better still, a blender)
- hot water
- a very strong magnet
- clean white paper
- a clear, sealable plastic sandwich bag

WHAT DO I DO?

Fill the cup to about two-thirds full with cereal, and with the spoon or pestle crush the cereal into a fine powder. It is worth spending a lot of time on this stage – the finer the powder, the better.

Put the crushed cereal into the sandwich bag and add hot water. Leave the mixture for about 15 to 20 minutes. Now gently tilt the bag forward so that the cereal collects on one side, and place the magnet along the outside of the bag near the cereal, running it over the bottom, because the iron tends to sink. Tilt the bag back so that the cereal runs away from the magnet. You can also lay the bag flat on the table and stroke it with the magnet towards one corner.

Alternatively, if you are using a blender, put the cereal straight into the blender and add hot water until the cereal is submerged. Wait for about 15 to 20 minutes until the cereal is soft, then blend it all together. While the blender is whirring, place the magnet on the outside of the blender near the mixture, and keep it there as you turn the blender off.

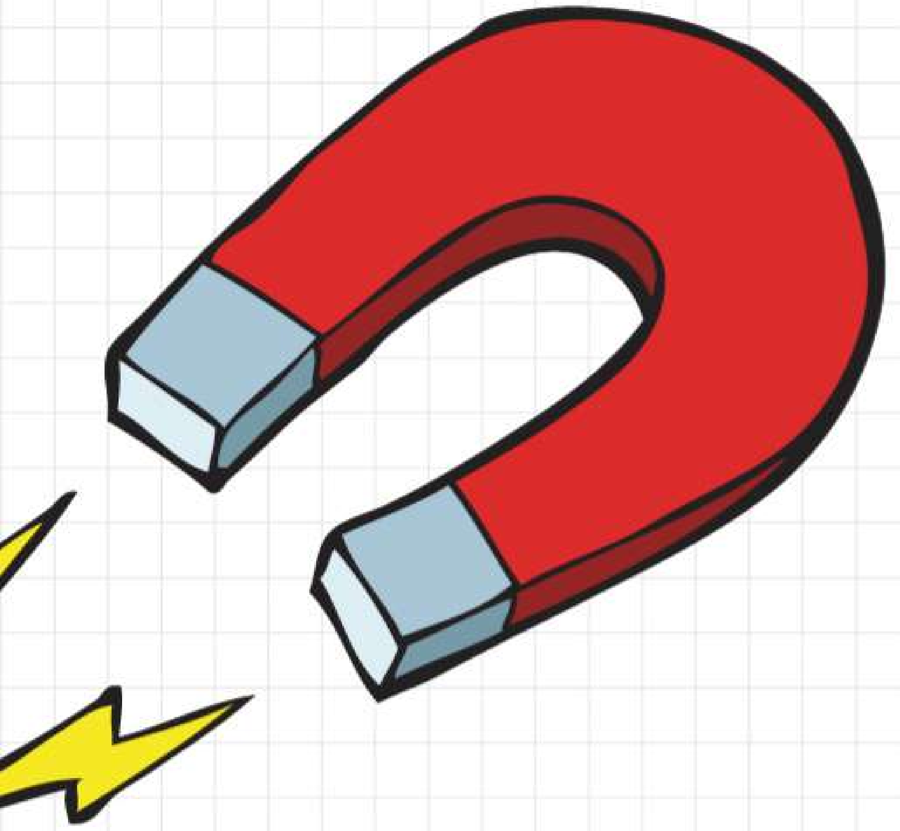


WHAT WILL I SEE?

The magnet will attract a black fuzz of iron. Move the magnet over the surface of the bag or blender and the tiny pieces of iron will follow it.

WHAT'S GOING ON?

The black stuff really is iron in your cereal – the same stuff that is found in nails and trains and motorbikes. And it's quite heavy, which is why you need to make sure you run your magnet along the bottom of the cup. The iron is added to the mix when the cereals are being made and you really do eat it when you devour your cornflakes.



The reason it is added in a form that you can extract is that iron ions (iron that would more easily combine with other molecules in the cereal) would increase the spoilage rate of the food. Using iron in its pure metal form gives the cereal a longer shelflife. The hydrochloric acid and other chemicals in your stomach dissolve some of this iron and it is absorbed through your digestive tract, although much of it remains untouched and comes out in the loo.

DEDMAZAY/ISTOCKPHOTO.COM

Humans need iron for many important bodily functions. Red blood cells carry haemoglobin, of which iron is a key constituent. Haemoglobin transports oxygen through the blood to the rest of the body by binding oxygen to its iron atom and carrying it through the bloodstream. As our red blood cells are being replaced constantly, iron is an essential part of our diet.

WHY DO BOYS HAVE NIPPLES?

Made especially for young and curious minds, *Why Do Boys Have Nipples?* (published as *Where Do Astronauts Put Their Dirty Underwear?* in the US) is based on *New Scientist*'s ever-popular Last Word column, and features 73 other weird questions only science can answer, plus plenty more fun experiments to try at home, too

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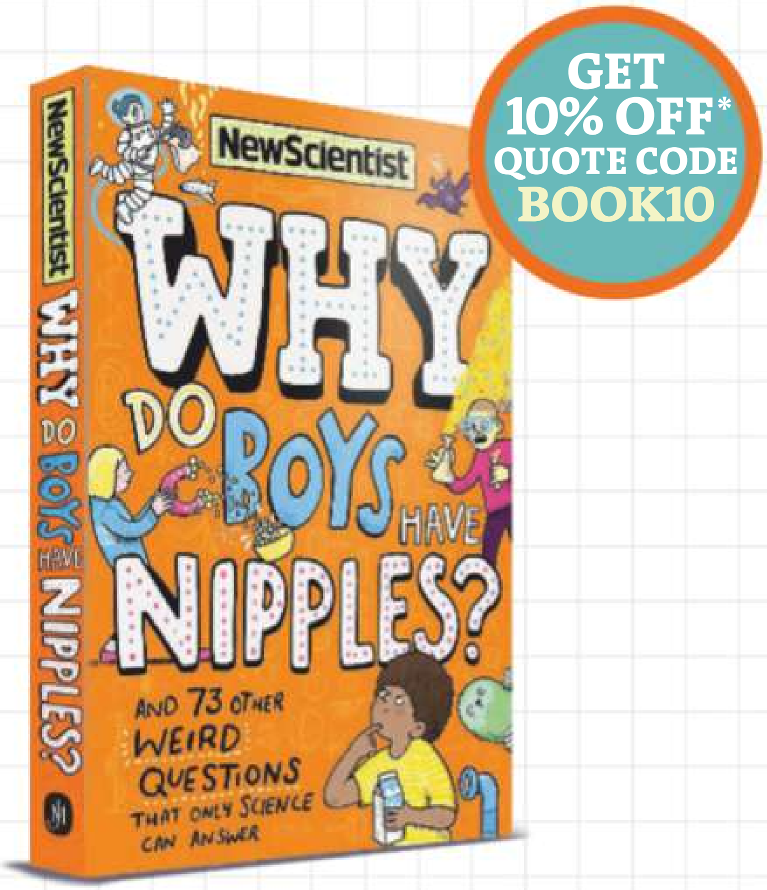
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NewScientist
WHY DO BOYS HAVE NIPPLES?
AND 73 OTHER WEIRD QUESTIONS THAT ONLY SCIENCE CAN ANSWER

LEARN TO BE A SCIENCE JOURNALIST

New Scientist is the world's most popular weekly science and technology magazine. Founded in 1956 for "all those interested in scientific discovery and its social consequences", the publication's teams in London, Boston and Sydney cover international news from a scientific standpoint, and ask the biggest-picture questions about life, the universe and what it means to be human.

These fundamental questions are of interest to everyone, whatever their background. But science and journalism both suffer from a lack of diversity, with many talented individuals and valuable perspectives excluded or lost from these fields.

That is why we are running our internship programme again this year. The programme is a learning and development opportunity open to anyone from a BAME (black, Asian and minority ethnic) background and will offer a six-month internship starting in October. The internship will pay the 2020 London Living Wage and be based on the London news desk. We cannot yet confirm if it will be office-based or working from home.

Interns will receive mentoring and on-the-job training in news and feature writing, as well as in subediting. By the end of their placements, they will have an extensive portfolio of published work.

The only entry requirements are that you have completed a science, technology or computing degree by the start of the internship, and that you have a demonstrable interest in writing or journalism. We ask applicants to submit 200 words explaining how you meet these requirements, and why you are the right person for this internship. We also ask applicants to write an article, between 500 and 800 words long, on a recent scientific discovery. To apply, please visit: tinyurl.com/NSInternship

The internship is a positive action scheme, under the Equality Act 2010.

NewScientist Diversity Internship Programme

We are HIRING

Physics and technology feature editor

New Scientist is the world's leading weekly science and technology magazine. We are currently seeking a physics and technology feature editor to help shape our leading coverage of physics, cosmology and technology.

The ideal candidate will work closely with colleagues to provide the highest quality journalism and develop innovative ways to present stories in print and online for our international readership.

The winning candidate will have significant feature writing and editing experience for a national or international news organisation. They will also be able to demonstrate a passionate interest in both science and technology.

The ideal candidate will also have an excellent working knowledge of digital journalism, SEO and ideally audio and video production. They will be enthusiastic about collaborating with the commercial, marketing and new product development teams to help expand the *New Scientist* audience.

This is going to be a very hands-on position within a fairly small, but highly dedicated group of expert science journalists.

We welcome applications from anywhere in the world, and from a diverse range of candidates.

To apply, please visit **jobs.newscientist.com**. Ref code: **NSFE**

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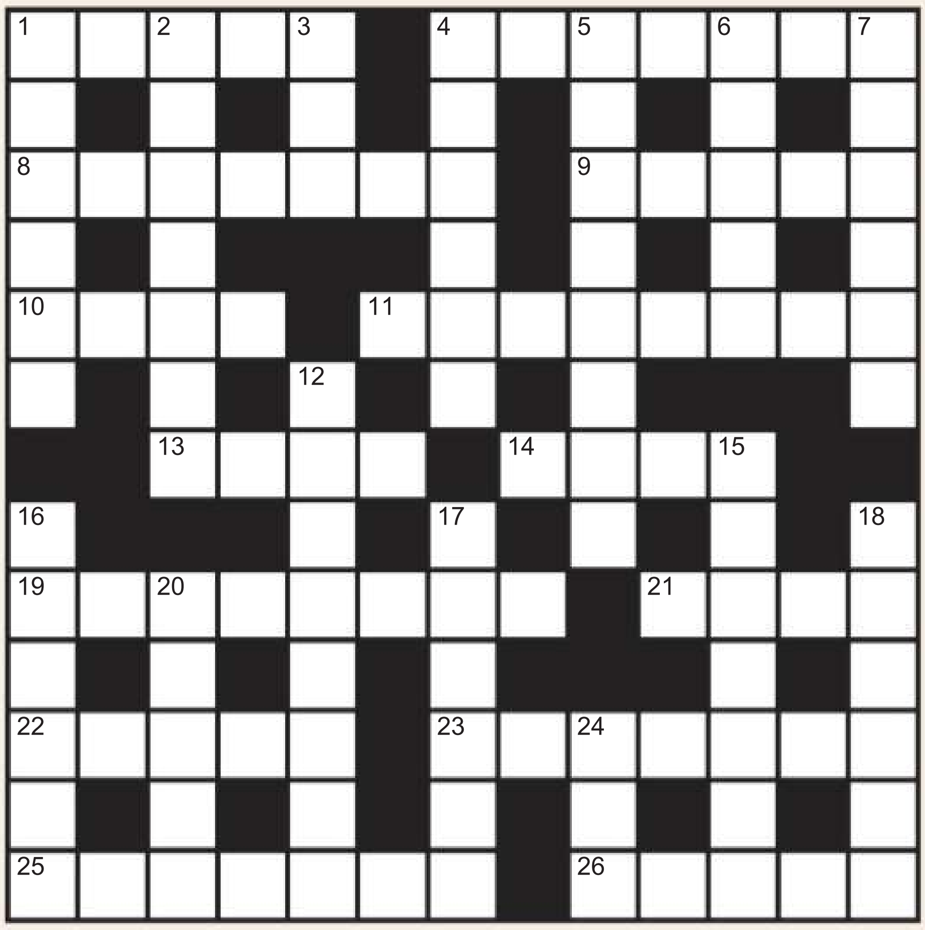
Puzzle
A stripy flag, a pair of scissors and a problem to solve **p54**

Cartoons
Life through the lens of Tom Gauld and Twisteddoodles **p54**

Feedback
Social distancing with Australia's deadly fauna **p55**

The last word
Why don't trees get really wide? Readers respond **p56**

Cryptic crossword #36 *Set by Wingding*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 US author excluding one with good accent (5)
4 Source of poison has hair on the edge (7)
8 Endlessly request basic reproduction number under laboratory conditions (2,5)
9 Bit of coriander stalk making religious doctrine (5)
10 Instrument supplied by top bloke on the regular (4)
11 Possibly a bacterium with sexual partner, one under lockdown? (8)
13/14 Do housework and stretch, short of energy, as a means of ventilation (4,4)
19 Encourage study covering last three components of blood clot (8)
21 See 7 Down
22 Teacher went for a dip before one (5)
23 See 3 Down
25 Livestock farmer dashed towards singer (7)
26 *New Scientist*, perhaps, with a degree? Hot stuff! (5)

DOWN

1 Moon has sci-fi film about it (6)
2 Part of valve Oliver kept in pockets (7)
3/23 Across Instinct to pull back and charge fish (3,7)
4 Hang around capital of Ohio for president (6)
5 Part of fungus indicated by setter's clue? I'm baffled (8)
6 A stone circle erected, ending in Greece (5)
7/21 Poor blind Yankee giving away lotus root for source of protein (6,4)
12 Member of school supporting fossil fuel, a resource in the Atlantic (8)
15 Headless giant with dark side, gradually at first showing his age (7)
16 See 20 Down
17 Cow's successor absorbs iron (6)
18 Organic compound rising over top of glass - it's a mystery (6)
20/16 Artisan beer cocktail? That's puzzling (5,6)
24 Apples start falling out as boy climbs tree (3)

Quick quiz #61

1 The European eel (*Anguilla anguilla*) is thought to breed in what shoreless sea, 6000 kilometres from its native waters?

2 If consumed raw, eel blood causes what toxic shock reaction in people?

3 China is estimated to have become the world's largest eel consumer in 2007, although the numbers are slippery. What country did it overtake?

4 In what way is the name "electric eel" misleading?

5 With what interpretation of quantum theory does Mark Oliver Everett, singer-songwriter of US rock band *Eels*, share a progenitor?

Answers on page 54

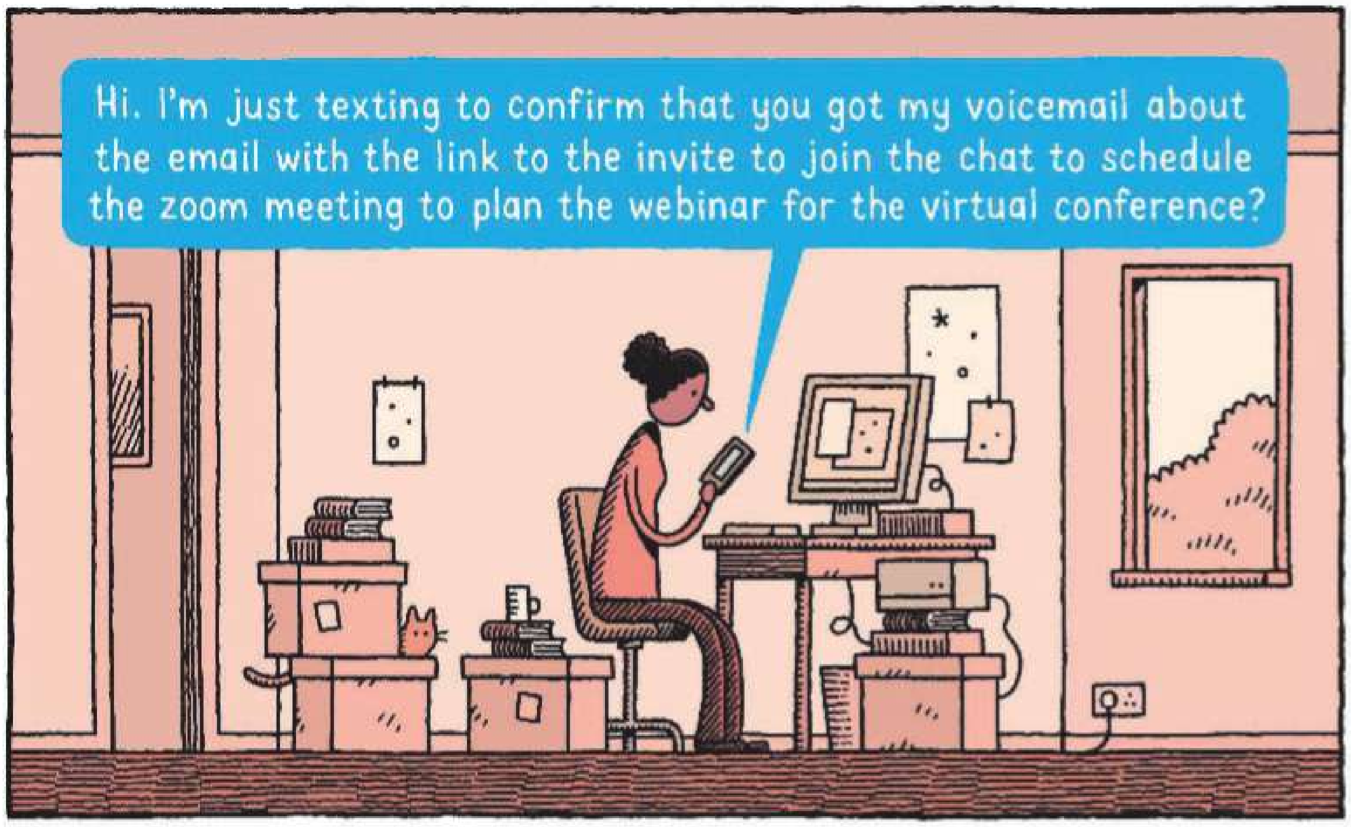
Quick Crossword #62
Answers

ACROSS 1 *Ardipithecus*, **10** Allegro, **11/26** Darwin's bulldog, **12** Lobes, **13** Pandemic, **15** Percentile, **16** Echo, **18** Acre, **20** Pitchstone, **22** Tendrils, **24** Adler, **27** Abiotic, **28** Text-To-Speech

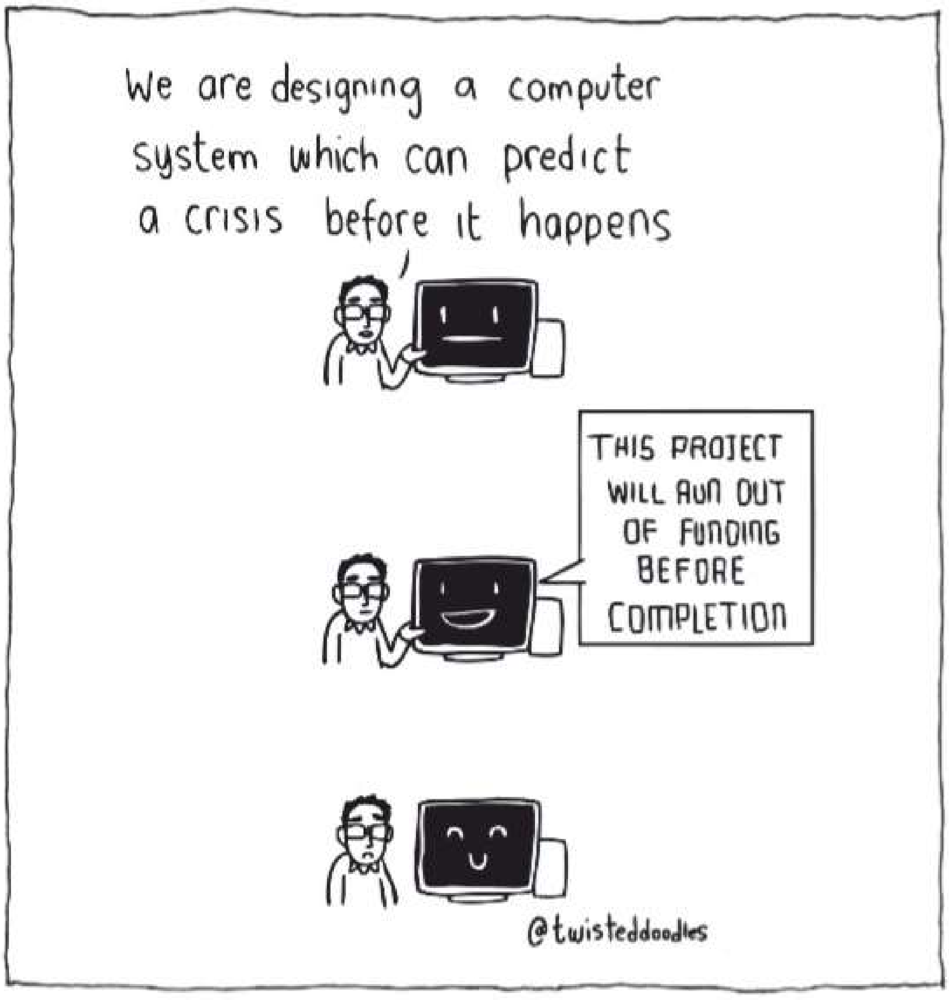
DOWN 2 Roll bar, **3** Ingested, **4** Igor, **5** Hydraulics, **6** Cured, **7** Seismic, **8** Fallopian tube, **9** Psychometrics, **14** Strip light, **17** Astatine, **19** Ringlet, **21** Oolitic, **23** Radix, **25** Mars

Our crosswords are now solvable online
newscientist.com/crosswords

Tom Gauld
for New Scientist


Hi. I'm just texting to confirm that you got my voicemail about the email with the link to the invite to join the chat to schedule the zoom meeting to plan the webinar for the virtual conference?

Twisteddoodles
for New Scientist


We are designing a computer system which can predict a crisis before it happens
THIS PROJECT WILL RUN OUT OF FUNDING BEFORE COMPLETION
@twisteddoodles

Quick quiz #61
Answers

1 The Sargasso Sea in the Atlantic; many details of the eels' spawning and migration remain mysterious, however

2 Anaphylaxis

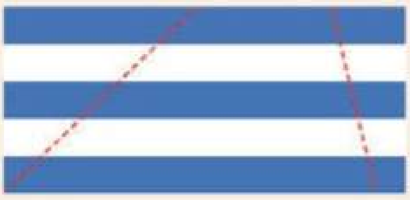
3 Japan

4 The electric eel *(Electrophorus electricus)* isn't actually an eel, but a knifefish; its electricity is genuine, with 80 per cent of its body given over to generating it

5 The many worlds interpretation; his father, Hugh Everett III, originated it in 1957

Puzzle
set by Catriona Shearer

#69 Cutting the flag



I have a stripy flag laid out on my desk. The stripes are all of equal width, five of them in total. Because three of the five are blue, I know that three-fifths of the flag is blue. However, I take my scissors out and make two straight, angled cuts at both ends of the flag, one of them at about 45 degrees, the other almost straight across, leaving me with a stripy trapezium. What fraction of this trapezium is blue? Is it more, less or the same as the three-fifths for the original flag?

Answer next week

#68 Diamonds

Solution

There were no diamonds in the box. Call the number of palaces P. There were P^2 vases and P^3 diamonds, of which Fidelio got P, leaving $(P^3 - P)$ to share among the six daughters. Whatever value you choose for P, you'll find that $P^3 - P$ is exactly divisible by 6, so all the remaining diamonds went to the daughters. Why? Because it is equivalent to $P \times (P+1) \times (P-1)$, the product of three consecutive numbers, one of which must be divisible by 3, and at least one of the others divisible by 2, making the product divisible by 6.

Casso-wariness

It has been a while since Feedback last covered units of measurement used in guidelines for social distancing. That's partly because we thought we had spotted all the good ones, but also, we confess, because we took our eye off the ball. So we are grateful to Simon Kravis for his example from the signage at Cairns Airport in Queensland, Australia.

According to a news story from ABC, the airport is planning to use the length of the cassowary – a flightless Australian bird – to keep travellers the necessary distance apart. Adult cassowaries are apparently around 1.5 metres from nose to tail, so imagining that one exists between you and your nearest neighbour seems like sound advice. But with claws that can exceed 10 centimetres in length and a predisposition for kicking nosy passers-by, you are probably going to want to stay even further away from that imaginary cassowary. Those travelling through Cairns are likely to be very socially distanced indeed.

JOSIE FORD

Got a story for Feedback?

Send it to feedback@newscientist.com or
New Scientist, 25 Bedford Street, London WC2E 9ES
Consideration of items sent in the post will be delayed

Amen to that

Feedback would be nothing without our colleagues. They selflessly share with us their anecdotes and expertise, keep us informed of the goings-on in the world and are always willing to trawl the depths of their spam folder for entertaining nuggets.

This week's nugget is particularly amusing, for, after a bit of throat-clearing, it runs: "churches like NEW SCIENTIST are struggling more than ever during the new normal. Giving, attendance, events, and more are down or non-existent." We hear you, unnamed email sender, we hear you.

That's why, it continues, "you will have 6 months to take advantage of a complete risk-free church solution". If risk-free solutions are available, then rebranding as a religion is certainly an attractive prospect. But we are curious to know what our distinct appeal might be. What sort of rituals would we engage in? What holy texts – if any – would we adhere to? Your offerings (via email, post or bank transfer) are welcomed.

Have you finnished?

Nominative determinism in English? Old news. Hackneyed. Boring. Nominative determinism in Finnish? Exciting. Frisson-inducing. Moreish.

This is Feedback's new policy, spurred on by an email from Ilpo Salonen who informs us that a leading figure at the Finnish mining and metal-refining firm Metso Outotec is called Markku Teräsvasara. The Finnish speakers among you will scarcely need to be reminded that this surname translates as "Steelhammer". "What a waste of a useful heavy metal band name," says Ilpo. Ba-dum-tsh.

I spy a joke

Scientists shouldn't be allowed to name things. All too often, they crowbar in their own names or come up with an unconvincing pseudo-acronym that elicits groans at every conference. Or, if they are astronomers, they just go with a dull and pedestrian option. This mindset has gifted us the (existing) Very Large Telescope, the (soon to be) Extremely Large Telescope and the (perhaps mercifully cancelled) Overwhelmingly Large Telescope.

Unabashed, Anna T. P. Schauer, Niv Drory and Volker Bromm have uploaded a paper to the arXiv preprint server in which they speculate about a hypothetical Ultimately Large Telescope. It is so powerful that it can see back to the cosmic dawn when astronomers finally lost the spark of creativity.

Fake News-scientist

Nine times out of 10, when Feedback comes across a humorous fragment of text on the internet purportedly written by an AI, the trace of a human hand is clearly apparent. Items in the exceptional 10 per cent have – so far at least – originated from GPT-2, a text-generation programme developed by OpenAI. Its fearsome ability to predict what should follow a given sample of text led to its creators not releasing the full version, for fear it be used to create fake news indistinguishable from the real thing.

It turns out that a comparatively well-kept corner of the internet forum Reddit is devoted to the output of GPT-2, wherein every post, comment and response is artificially generated. And lo and behold! Among the recent threads is one responding to a completely made up New Scientist headline: "Human body is the oldest DNA ever discovered and it came from a fossil of a human who was 2000 years old."

Indistinguishable from the real thing, eh? But while our subeditors may not be quaking in their boots just yet, it is the comments that really confound us. "That's a new record for us humans," says one. "You got to admit, it's pretty cool to look at old genetic sequences being compared to other old genetic sequences," says another.

"I'm not sure how much weight this paper holds," begins a third, with laudable scepticism, adding that "the fossil is from the Hoxne-Dahydran culture, which is the earliest known culture to have agriculture and a complex society. This is the only known evidence for a pre-agricultural society anywhere in Europe."

Astonishingly coherent, distinctively erudite and, alas, involving entirely made up facts. As a simulated version of an online comment, that takes some beating. ▮

Written by Gilead Amit

Spreading roots

If the height of a tree is limited by capillary action, why can't trees grow to an unlimited width?

Guy Cox
St Albans,
New South Wales, Australia

This takes me back to my plant science degree. First of all, capillary action doesn't limit the height of trees. If it did, they would be nothing like the magnificent specimens we see all around us.

Water transport in trees depends partially on water molecules sticking together to form a column in hollow cells within the bulk of the trunk. This is distinct from capillary action and therefore no fundamental limit exists on the height of a tree.

It isn't clear that anything limits the girth of trees either, but the trunk functions to support the crown. In a forest, the primary consideration is to get the crown high enough to catch the sun.

Ancient, slow-growing trees can have very broad trunks – this is seen in the redwoods of the Sierra Nevada mountain range in the US, which can be more than 3000 years old and have trunks about 10 metres in diameter. In Australia, we have the largest broadleaved trees in the world, reaching heights in excess of 100 metres, but they are relatively fast growing and short lived.

Trees in isolation can spread very widely. Two oaks in England – the Newland Oak, Gloucestershire, and the Cowthorpe Oak, North Yorkshire – reportedly had trunks more than 5 metres in diameter. Both were relics of ancient forests, but once freed from vertical competition, they spread horizontally. Though they are now both dead, the Newland Oak was about 1000 years old and the Cowthorpe Oak lived for up to 1800 years.

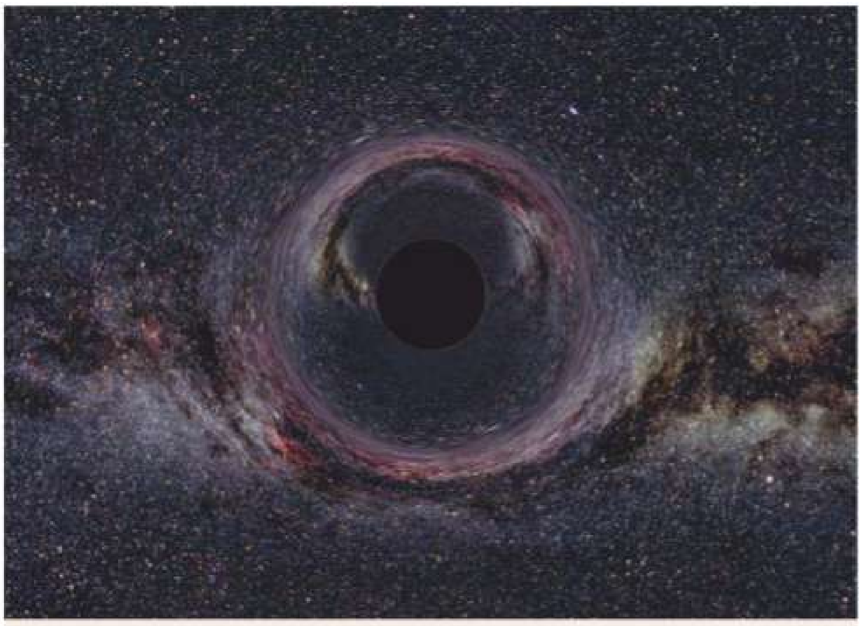
In the case of the Newland Oak, its large horizontal spread was probably encouraged by pollarding – the practice of harvesting branches for timber.

Mike Follows
Sutton Coldfield,
West Midlands, UK

The function of a tree trunk is to provide support for the branches, which carry leaves for photosynthesis, as well as being a conduit for water. The trunk won't grow wider than it needs to be as building that extra tissue would be a waste of energy.

It also won't be too narrow, however. If a tree were too thin for its height, it would buckle. The minimum diameter required to prevent a cylindrical column buckling under its own weight is proportional to its height to the power of 1.5. Trees largely obey this relationship, but with some variation between species and among individual trees within each species.

Trees can also develop wider trunks if exposed to the wind. This should mean that trees on the edge of a forest have thicker trunks. Indeed, it is often the spindlier trees away from the edge of a forest that are toppled during severe storms. This is probably because these trees aren't adapted to the strong wind that can penetrate further into a forest on such occasions.



UNIVERSAL HISTORY ARCHIVE/UNIVERSAL IMAGES GROUP VIA GETTY IMAGES

If dark matter fell into a black hole, what would it look like?

This week's new questions

Small torque **How do food packaging companies decide how tight to make the lids on jars? Has this increased over time or am I just getting older?** ***Paul Stapleton****, Santa Fe, New Mexico, US*

Doubly dark **What would it look like if dark matter fell into a black hole? What might you see while it was happening?** ***Patricia Finney****, Falmouth, Cornwall, UK*

Cyclic logic

A triplet bike is lighter and has less resistance per person, so is more efficient than a tandem, which is more efficient than a regular bike. Does this trend hold however long the bike?

Cedric Lynch
Potters Bar, Hertfordshire, UK

Multi-seat bicycles get more efficient the more seats they have, up to the point where the builder is forced to adopt motorcycle tyres instead of bicycle tyres in order to accommodate the weight.

There is then a large drop in efficiency because motorcycle tyres typically have a rolling resistance coefficient – the horizontal force needed to roll the wheel on a level surface, expressed as a fraction of the weight on the wheel – about four times that of bicycle tyres.

The bicycle in your photo is for three riders, one or two of whom are children. Thankfully, there are bicycle tyres available that can comfortably support this weight.

N. C. Friswell
Horsham, West Sussex, UK

It depends on how "efficiency" is measured. In the 1950s, I owned a tandem bike and my fiancée and I decided to go on a touring holiday to Land's End in Cornwall. When we got to the Cornish hills, we found that they were impossible to cycle up, even with the combined weight of the two of us standing on the pedals.

When I mentioned this to a cycling enthusiast, he said: "What do you expect? Hill-climbing trials bikes have very short wheelbases. The tandem is long." But he was unable to explain why short-wheelbase bikes were able to get up hills easier. Clearly, in this respect, the tandem isn't more efficient and the triplet bike in your illustration must be completely useless in hilly areas.

Eric Kvaalen
Les Essarts-le-Roi, France

As a bike gets longer and longer, it eventually has to get wider and taller as well. It wouldn't be possible to make a bike that was a mile long using struts with the same diameter as those for a normal bike.

Eventually, the weight would rise faster than is proportional to the length, whereas the number of riders would still be proportional to the length. As such, the weight per rider would increase. ▮

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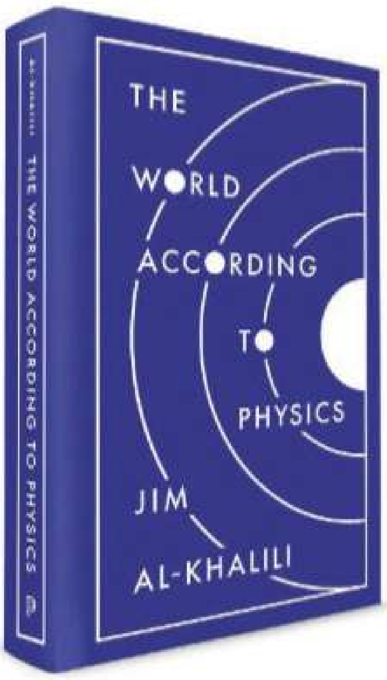

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